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IMPACT OF UNILATERAL AND BILATERAL RESISTANCE AND PLYOMETRIC TRAINING ON SELECTED FITNESS ELEMENTS AND STRIKING VARIABLES AMONG SOCCER PLAYERS

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Thesis

Submitted by

TUBIN S

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ABBREVIATIONS

URTG – Unilateral Resistance Training Group

UPTG – Unilateral Plyometric Training Group

BRTG - Bilateral Resistance Training Group

BPTG - Bilateral Plyometric Training Group

CG – Control Group

RHR - Resting Heart Rate

HRmax- Maximal Heart Rate

bpm – Beats per Minutes

MS - Muscular Strength

AP - Anaerobic Power

SE - Strength Endurance

EP - Explosive Power

AF - Aerobic Fitness

KA - Kicking Ability

DA - Dribbling Ability

PA - passing Ability

SA - Shooting Ability

Df – Degrees of Freedom

SoV – Source of Variance

B – Between

W – Within

MS – Mean Square

SS – Sum of Square

MD – Mean Differences

CI – Confidence interval

Chapter I

INTRODUCTION

Soccer is the most popular sport in the world, and as a result of its immense popularity, numerous studies have been undertaken to better understand the essential qualities necessary of a soccer player. Over the last two decades, soccer game is becoming more and more athletic and players' ability to perform a variety of strong and explosive activities, such as jumping, running, tackling, turning, kicking and changing tempo, has become critical in many game circumstances (Reilly, Bangsbo & Franks, 2000; Castagna et al., 2003). Because it has been previously reported in notational game analyses, these concerns are becoming increasingly important to optimal performance not only in adults but also in young players in the modern football approach (Stroyer, Hansen & Klausen, 2004; Castagna et al., 2003). High-speed running, for example, accounts for up to 3% of total distance travelled in children's games (Castagna et al., 2003), and the game's most vital moments, such as surrendering goals, scoring goals, or winning ball possession are all dependent on it (Reilly, Bangsbo & Franks, 2000). Such explosive actions are crucial for soccer performance and must be cultivated separately from aerobic power with the right training stimulus (Helgerud et al., 2001).

Physical performance enhancement has been a major aspect in developing soccer athletes, especially in the professional ranks, over the last decade. Strength and power development has been emphasized in their training in order

to reduce injuries, stay stronger throughout the season, and enhance the players' speed and physical abilities. Maximal strength is the first attribute to improve in terms of training before beginning to utilize power training. Power is a "product of force and the inverse of time, more particularly the ability to produce as much force as possible in the shortest feasible time" and can be produced if an adequate strength basis has been developed (Hoff & Helgrud, 2004).

Soccer players are needed to frequently generate maximal or near maximal sprints of short duration (1 - 7 seconds) with limited rest intervals, therefore soccer coaches and programmes place a high priority on training the players' repeat-sprint ability (Rampinini et al., 2007). Soccer needs several single leg, or unilateral activities, such as jumping, cutting, running, twisting, kicking and bracing against a defender, over a lengthy period of time in addition to energy system development. When a player dribbles, passes, or shoots the ball, one leg is dominant in order to powerfully move the ball while the other leg supports the body weight (Oshita & Yano, 2010). One of the underlying themes of this study is that, in order to improve physical performance and make training more relevant to actual sport performance, unilateral and bilateral resistance and plyometrics, as well as the ability to develop and absorb force in all planes going forward, laterally, and vertically, training must emphasise unilateral and bilateral resistance and plyometrics.

Unilateral and Bilateral Resistance Training

Resistance training is a common place for team sport athletes with the ultimate aim being the transfer of heightened physical capacity to superior sporting performance (McGuigan, Wright & Fleck, 2012). Bilateral resistance exercises such as squats, deadlifts, and weightlifting derivatives have been demonstrated to improve strength and 5–40-meter speed performance and thus incorporated in resistance training programs for elite athletes (Seitz et al., 2014; Comfort, Haigh & Matthews, 2012; Hoffman et al. 2009). However, given that key phases of athletic performance such as sprinting and change of direction (COD) occur in 1 leg, unilateral resistance training is perceived to offer greater movement specificity than bilateral exercises (McCurdy et al., 20-05; Speirs et al., 2015).

Owing to a single base of support, unilateral resistance exercises are considered sport specific (Jones et al., 2012; McCurdy & Conner, 2003). The unstable nature has demonstrated altered neuromuscular activation levels in gluteal, hamstring, and quadricep muscle groups compared with bilateral movements (McCurdy et al., 2010; DeForest, Cantrell & Schilling, 2014). Several lower-limb musculotendinous injuries are attributed to neuromuscular deficits, which may be rectified by targeted unilateral training (Tyler et al., 2006). Coupled with the resemblance of sporting movements, unilateral exercises are recommended for rehabilitation requiring enhanced neuromuscular coordination (Beutler et al., 2002). However, the unstable base may also reduce

the magnitude of external load required for strength development and subsequent improvement in sports performance in trained individuals (Behm, Anderson & Curnew, 2002).

Studies investigating the effect of unilateral vs. bilateral resistance training have reported similar strength outcomes, inferring equal benefit using either of the two (McCurdy et al., 2010; Speirs et al., 2015). Investigating bilateral and unilateral resistance training involves several practical limitations making sound methodological designs challenging and findings difficult to apply. These include the training age of subjects, inadequate familiarization and training period duration, unadjusted differences in pre-training performance, insufficient resistance training stimulus, and supplemental exercise prescription (Speirs et al., 2015; Fisher & Wallin, 2014; Gonzalo-Skok et al., 2016). For example, although improvements in unilateral basketball performance have reported the adolescent age of subjects (average age 17 years), this may have little application to mature athletes (Gonzalo-Skok et al., 2016).

Furthermore, isolating the transfer of unilateral or bilateral resistance training is problematic where studies have incorporated additional generic lower-body resistance training or unilateral and bilateral plyometrics (Fisher & Wallin, 2014; Gonzalo-Skok et al., 2016). Sufficient overload may also have been compromised by short periods of intervention (Speirs et al., 2015) or magnitude of resistance training intensity by external loading (Fisher & Wallin, 2014;

Gonzalo-Skok et al., 2016). Therefore, such constraints make it difficult to isolate effective resistance training strategies for athlete training programs.

Although inherently unstable on 1 foot, the barbell step-up (step-up) is a unilateral exercise that uses considerable external loading capable of driving strength adaptation. Despite the initial bilateral base of support, the majority of the movement is entirely unilateral, unlike other “unilateral” exercises such as lunges, or rear foot elevated split squats, that are asymmetrical rather than purely unilateral. Although the step-up seems to exhibit sport specificity as an unstable strength development exercise, little research has examined its application to improvements in fitness elements and soccer performance. Therefore, the aim of this study was to examine the changes in fitness elements and striking variables as a result of resistance training using either bilateral only or unilateral only.

Unilateral and Bilateral Plyometric Training

Plyometric training is an important part of many fitness professionals' routines for improving strength and power in a variety of sports (Ramirez-Campillo et al., 2018; Davies et al., 2015; Bogdanis et al., 2019). The stretch-shortening cycle, which permits muscles to store elastic energy during a quick eccentric muscle contraction and then release it during the subsequent concentric muscle contraction, is a key feature of lower-limb plyometric workouts like jumps and hops (Enoka, 2015). Plyometric training is becoming more popular in sports, with numerous studies demonstrating significant increases in jumping

ability, maximal strength, speed, acceleration, and agility (Michailidis et al., 2013; Thomas et al., 2009; Fatouros et al., 2000).

Plyometric exercises are popular in soccer training because they are simple to practise and combine with other sport-specific explosive activities, and they don't take up a lot of time, space, or equipment (Michailidis et al., 2013; Faigenbaum et al., 2007). High degrees of agility, power, and efficient use of the stretch-shortening cycle are required for competitive soccer performance during short-duration peak exertion (Ribeiro et al., 2019; Ramirez-Campillo et al., 2018; Thomas et al., 2009). In high-level soccer, a study found that exceptional players picked for the national team outperformed non-selected players in the above characteristics (Ramirez-Campillo et al., 2015). Plyometric exercises strengthen these kind of physical qualities and, as a result, could be used in soccer training to improve performance in movements such as accelerations, decelerations and direction changes. (Michailidis et al., 2013).

Plyometric training may be a useful training method for increasing performance in preadolescent athletes because jumping and leaping are fundamental skills in various sports (Johnson et al., 2011). Because of the high damage risk for bones and tendons, it is recommended that young athletes begin plyometric training with their own body weight and avoid high impact plyometric activities (deep jumps) (Michailidis et al., 2013; Fatouros et al., 2000). Coaches should consider athletes' age and level of expertise, as well as their injury histories, while implementing a comprehensive plyometric training

programme (Davies et al., 2015). Furthermore, in order to minimise training overload, especially in preadolescent athletes, the fundamental principle of progressiveness on sets and repetitions of strength training should always be observed. (Davies et al., 2015).

Stretch-shortening cycle (SSC) muscle activities, such as plyometric training (PT), provide such training stimuli and are well-known approaches for improving athletic performance in strength and power events (Saezde- Villarreal, Requena & Newton,2010; Saezde-Villarreal, Requena & Cronin, 2012; Markovic, 2007). Factors including eccentric overloading, segmental coordination, muscular power, and specificity according to joint angle and angular velocities could all contribute to a plyometric method's success (Schmidtbleicher, 1992). To the authors' knowledge, only a few studies have determined the best PT design for a variety of powerful and explosive motions like running, jumping, kicking, turning, and changing pace (De-Villarreal, 2009). Furthermore, when it comes to the impact of PT on soccer players' motor function, research has primarily concentrated on adult soccer athletes rather than young children soccer players (McKay & Henschke, 2012; Johnson, Salzberg & Stevenson, 2011).

Due to the importance of specificity in training-induced adaptations, performance changes in explosive neuromuscular actions may necessitate specialised training regimens that take into account the multi-planar and unilateral nature of most competitive soccer movements (Meylan et al., 2014).

As a result, soccer-specific training interventions that include multi-directional unilateral and bilateral force production exercises are required. Although knowing the characteristics of single exercises is useful when creating training programmes (Makaruk, 2011), knowing the effects of unilateral and bilateral exercises is crucial because these types of muscle activity are present during soccer games.

Benefits of Unilateral Training

To combat rotational forces and unwanted movement, and to maintain quality form, requires the use of the body's stabiliser muscles (Carroll et al., 2006; Uh et al., 2000). Unilateral training has been shown to have a crossover effect because when we are working one side, the other side is also affected to a minor extent (Hale et al., 2014). With the crossover affect, there will not be as great a strength loss in the injured muscle, which will result in quicker recovery time to previous strength levels (Hale et al., 2014; Behm et al., 2005).

The bilateral deficit simply refers to when the sum of the maximum weight lifted by both limbs in a unilateral exercise, for example, the lunge, would be less than the total lifted in a bilateral exercise like the squat. There are many factors to consider here such as biomechanics, training age and stabilizer muscle recruitment. However, the bilateral deficit is very apparent in untrained individuals and can be very beneficial to help fix imbalances (Saeterbakken & Fimland, 2012; Simenzm et al., 2012).

Most movements in everyday life require us to be moving our legs and arms unilaterally, climbing the stairs, walking or running involve the limbs being used separately (McCurdy et al., 2005*;* Hoffman, 2012). Certainly we should look at strengthening these specific movement patterns, particularly for more senior individuals who want to reduce their risk of falling or losing balance. Unilateral exercises can be used to help target and isolate weaker or inactive muscles, like getting the glute medius firing before a squat session with some single leg hip thrusts.

Benefits of Bilateral Training

Bilateral lifts produce greater force production and power enhancements in trained individuals. The ability to move more weight, at a fast velocity means that force production and power enhancements can be achieved (Hermassi et al., 2011). Bilateral exercises have the ability to increase strength quickly through greater total load on the body's musculature and central nervous system compared to unilateral resistance training alone. Strength based sports and competitions like power lifting and Olympic weightlifting revolve around big bilateral movements. Bilateral exercises may be the better choice for those lacking confidence or experience to help build a base level of competence before progressing onto more difficult unilateral exercises. Bilateral exercises require less mental concentration and body awareness to maintain good.

Trained individuals who are strong in a bilateral lifts, such as the barbell chest press tend to have a good strength transfer to the unilateral variation, like

the single-arm dumbbell chest press in a relatively short amount of time. Explosive bilateral exercises are considered less risky to perform than the precarious positioning required for unilateral movements. The bilateral lifts have been a staple lift in exercise programming for generations of fitness professionals and practitioners**,** helping develop some of the most aspiring physiques and physical capabilities we have ever seen, so something must be working.

Essential Fitness Elements of Football Players

Fitness plays a very important role in a normal individual as well as in an individual who is there participating in some kind of sports events. There are different kinds of sports and games which are performed all over world some are related to each other but some are entirely different. So to perform these different kind of sports event physical fitness is an essential component which should be possessed by a player. To improve physical fitness of an player training plays a very important role, as the techniques which are given in training to a player improves the players performance give positive effects to his performance in events.

Soccer is the most glamorous sport containing different skills and activities such as jumping, tackling, and sprinting (Afifi, Balbaa & Saweeres, 2019; Ibrahim & Azhar, 2020). Football requires various physical and mental challenges where participants must conquer the action of defending and attacking. Ball control is crucial where variety of foot skills is involved and this is done under pressures or restricted space, limited time, determined challenges

opposed by the opponents and the most important aspect is the physical fitness level of the individual. The fast phase or rapidly changing situations during game requires the aspect of decision making abilities as well as overall endurance.

Football is a very demanding cardiovascular sport to retain a vertical stance throughout the game and be swift in their response of passing or dribbling the ball away from their opponent. To be successful in this endeavor they are required to resort in the direction of the high speed performance to maintain the flexibility as well as dodge many a seasoned opponents and tackle them with great agility. In addition, the players require have a greater level of skill to play football and be a successful player along with great physical fitness. Coaches who work with the players in the sport have a better understanding of the physical demands of the game of football.

Most resistance training research has investigated effects using bilateral strength exercises like the leg press, barbell squat, or barbell deadlift. The research regarding training for maximal strength using unilateral exercises pales in comparison to the research on bilateral barbell training. In practice, most coaches perform unilateral strength training, using exercises like rear foot elevated split squats, pistol squat variations, or single leg deadlift variations. Research has shown that the transfer of strength developed in bilateral training (e.g. using squats or power cleans) offers specific improvement in performance in bilateral events, while unilateral training (e.g. with dumbbells or split cleans) enhances performances more effectively in unilateral activity such as running,

jumping.” In recent peer-reviewed literature, the reported performance gains associated with unilateral strength training show similar effects to what is reported with bilateral strength training.

Both bilateral and unilateral power training will result in general adaptations associated with improvements in power, namely speed of muscle contraction, faster motor unit activation, enhanced neural firing rates, decreased duration of the stretch-shortening cycle, and improved proprioception. However, there are specific adaptations that occur depending on the training means used. Unilateral power and plyometric training are growing in popularity, especially with team sport athletes for whom having the ability to display power on one limb in multiple directions is an obvious advantage due to the demands of the game. Training in multiple planes seems to be an important factor, with research supporting the notion that having single leg power, deceleration, and coordination in multiple planes is an area of necessity when designing training programs for team sport athletes (Lockie et al., 2014; Maloney et al., 2019). Despite recent results showing unilateral and bilateral resistance and plyometric training can help young athletes develop many aspects of speed and power, there is still a need to enhance the characteristics of this sort of training specifically for soccer players.

Striking Abilities of Football Players

A game of football is not about mere dribbling or passing but is based on numerous football skills and techniques. Football being a strategical play has its

own techniques to execute a perfect kick. A strong offensive capacity is a basic requirement, especially for those offensive players. This is the basic skill of football that all the offensive players should practice on. The offensive line opens the door for running backs and prevents pass rushers from reaching the passer.

The most fundamental skills of football game are passing accuracy. To make use of both the feet in order to move the ball to the destined destination. The feet should always have the power and accuracy to pass the ball either to teammates or to the strikers for a goal. Passing skill is the one ultimate skill and football is devoid of an accurate and precise pass. The most efficient and basic skills for football is to dribble the ball, keeping it in possession. Run with the ball, is not as simple as it sounds, it needs good control, balance, coordination. To get a grab on it, move up and down the pitch with the ball in possession and maintain body control. A good dribbler can move the ball in multiple directions with various paces. The skill is to maneuver the opponent at a smooth pace without losing the ball's possession.

A perfect shot always ends up in the goal post, as a perfect goal. Shooting is the act of dispatching the ball to the opponent’s post. This is the ultimate thrust of the match because, at the end of the day, goals count teams win. This fundamental skill of football game requires both technical and mental qualities. To get the ball and kick it to the post, players have to do numerous tits and tactics in the field. One of them is tackling skills. It is not mere running and carrying the ball and applying shoulders, but the way one tackle the opponent. Tackling

skills are necessary to carry on with the ball in their grip. The basic way is to drive the shoulders to the opponents' hip, to the midsection before powering him to the ground.

Many training models have been used for the improvement of physical performance in soccer (Milanovic et al., 2015; Morgans et al., 2014). Moreover, the fact that these training models are compatible with the technical or technical-tactical skills of sport may contribute significantly to the efficiency of the training. Well-designed, unilateral and bilateral resistance and plyometric training models have recently been favoured by most soccer coaches, as they simultaneously affect technical skills, tactical awareness and conditioning development.

Need of the Study

According to research, a gain in maximal strength is frequently associated with an increase in relative strength and, as a result, with an improvement in power capacities (Hoff & Helgrud, 2004). Acceleration and speed in skills directly related to soccer, such as turning, sprinting, and changing pace, may increase by increasing force in appropriate muscles or muscle groups (Chelly et al., 2009). To score goals or prevent goals from being scored, players must be faster and stronger than their opponents (Chelly et al., 2009). All of the aforementioned motions necessitate muscular strength and power, which is why such physical characteristics are highly appreciated and frequently evaluated in soccer players (Rampinini et al., 2007). This study evaluated four different

training regimens based on past research, with the notion that strength is the foundation of all other athletic motions and performance. It was expected that after each of the training programmes, there would be an increase in physical performance measurements, which would transfer to better performance on the soccer field. In summary, the study's main goal was to compare the effects of unilateral resistance and plyometric training on soccer players' fitness elements to the traditional and still widely used bilateral-dominant programme. To the best of the researcher's knowledge, no studies have been conducted to compare the effects of a unilateral and bilateral resistance and plyometric programme on fitness elements and striking characteristics.

Despite the fact that soccer involves a lot of high-intensity movements like quick changes of direction (agility) and short-distance and short-duration sprints (speed), most players, fans and coaches regard it as an endurance sport. Cardiovascular endurance training might be stressed as a fundamental aspect of practice, an offseason training programme, or on an individual basis in a professional context. Off-field training such as lifting weights, plyometrics, and power training would receive less attention from most soccer coaches, programmes, and organisations due to this emphasis on cardiovascular endurance. Despite the fact that endurance training receives the most attention, several studies have shown that strength and plyometric training can improve jump height and speed while having no negative impact on cardio respiratory endurance (Siegler, Gaskill & Ruby, 2003; Gorostiaga et al., 2004).

Apart from the lack of agreement in terms of results, the relative effects of unilateral and bilateral resistance and plyometric exercises remain unclear. Some have speculated that unilateral and bilateral resistance and plyometric drills may provide greater benefits (Brown, Palmieri-Smith, & McLean, 2014); however, to the authors' knowledge, few studies have determined the relative effect of unilateral and bilateral resistance and plyometric exercises among soccer players. As a result, the goal was to see how unilateral and bilateral resistance and plyometric training affected the chosen fitness and striking variables in soccer players.

STATEMENT OF THE PROBLEM

Soccer is the most popular and widely watched sport on the planet, as well as one of the most diverse in terms of energy systems, performance metrics, and movement variation. Soccer, in particular, necessitates varying degrees of aerobic and anaerobic energy systems based on the game plan, opponent, and position played by the athlete. The goal of this research was to look into how a normal training programme is created, as well as the types of strength and power development training programmes that are currently used at the professional level. In addition, this research will build on current training protocols (unilateral and bilateral resistance and plyometric training) and assess the impact of a potentially more effective training method on fitness aspects and striking characteristics that could lead to increased soccer performance.

OBJECTIVES OF THE STUDY

The most important research objectives are:

1. To analyze the enhancement on chosen fitness elements and striking variables of soccer players due to unilateral resistance training.
2. To analyze the improvement on chosen fitness elements and striking variables of soccer players due bilateral resistance training.
3. To analyze the changes on selected fitness elements and striking variables of soccer players due to unilateral plyometric training.
4. To analyze the changes on selected fitness elements and striking variables of soccer players due to bilateral plyometric training.
5. To compare the effects of unilateral and bilateral resistance and plyometric training in improving the fitness elements and striking variables of players (soccer).

DELIMITATIONS

The delimitations of this investigation were.

1. This study was delimited to seventy-five male soccer players of age between eighteen and twenty-one years and they were selected from the Mohammed Sathak AJ Engineering College, Siruseri, Chennai and Hindustan College of Arts and Science, Padur, Chennai.
2. Participants were randomly assigned to five different training groups and one control group (15 in each group). Group-I performed Unilateral Resistance Training [URTG], Group-II performed Unilateral plyometric

training[UPTG], group-III performed Bilateral Resistance Training [BRTG] and group-IV performed Bilateral plyometric training [BPTG] and group-V was control.

3. The following fitness elements and striking variables namely muscular strength, anaerobic power, strength endurance, vertical explosive power, aerobic fitness, kicking, dribbling, passing and shooting abilities were chosen as dependent variables.
4. The total duration of the four different training protocols were limited to 3 training sessions per week for 12weeks.
5. By using the standardized test items, the chosen fitness elements and striking variables were assessed (before & after training).

LIMITATIONS

It has several limitations which may have some effect on the results derived.

1. Uncontrollable changes in climatic conditions, such as ambient temperature and other meteorological factors, were regarded restrictions during the treatment and also at the time of several tests (pre and post).
2. The chosen soccer player's growth and maturity, during the treatment period couldn't be restricted, therefore it was considered as a limitation.
3. No attempt was taken to control and also appraise the quality and amount of food intake by every person.

4. The physiological stress, way of life and quantum of physical effort that influence the metabolic functions was an another limitations.
5. Since, this work completed with a comparatively small sample size, which could not make the findings entirely representative of all soccer players.
6. The unilateral group required considerably longer to finish each training session, because they had double the repetitions of each of their main exercises. As a result, the bilateral group spent less total time training per session, which may have contributed to the unilateral group's overall weariness and stress following the 12-week programme.

HYPOTHESES

The investigator framed the following hypotheses.

1. There would be considerable improvement on chosen fitness elements and striking variables of soccer players due to unilateral resistance training (URT).
2. There would be significant improvement on chosen fitness elements and striking variables of soccer players due to unilateral plyometric training (UPT).
3. There would be significant improvement on chosen fitness elements and striking variables of soccer players due to bilateral resistance training (BRT).
4. There would be significant improvement on chosen fitness elements and striking variables of soccer players due to bilateral plyometric training (BPT).

5. The unilateral plyometric training would be better than unilateral resistance training (URT), bilateral resistance training (BRT) and bilateral plyometric training (BPT) protocols in improving the chosen fitness elements and striking variables.

DEFINITION OF THE TERMS

Soccer

It is a form of football played between two teams of 11 players, in which the ball may be advanced by kicking or by bouncing it off any part of the body but the arms and hands, except in the case of the goalkeepers, who may use their hands to catch, carry, throw, or stop the ball.

Unilateral Training

Unilateral training refers to working one limb/side of the body at a time.

Bilateral Training

Bi-lateral training means that working both limbs/sides simultaneously. Both limbs share the resistance and work together to move the load.

Resistance Training

Resistance training and strength training are synonymous terms used to denote a component of sport and exercise training that is designed to enhance muscular strength, muscular power, and local muscular endurance for general exercise or competitive sports.

Plyometric Training

Plyometric training is a method which combines strength and speed to produce power. "Plyometric exercises involve a lengthening or eccentric contraction of the muscles, immediately followed by shortening or concentric contraction of the same muscles – hence the jumping."

Muscular Strength

"The integrated result of numerous force-producing muscles operating maximally either isometrically or dynamically during a single voluntary effort of a given task," (Hoff & Helgrud, 2004).

Strength Endurance

A muscle's or a muscle group's ability to exert submaximal force against resistance for an extended length of time is known as muscular endurance. Often the resistance is the body itself. The measurement of muscular endurance is based on the number of repetitions performed.

Anaerobic Power

The maximum amount of adenosine triphosphate resynthesized via anaerobic metabolism (by the entire organism) during a given form of short-duration maximal activity is referred to as anaerobic power.

Explosive Power-Vertical

A vertical jump or vertical leap is the act of jumping upwards into the air. It can be an exercise for building both endurance and strength, and is also a

standard test for measuring athletic performance. It may also be referred to as a *Sargent jump*, named for Dudley Allen Sargent.

Aerobic Fitness

Aerobic fitness is a measure of our body's ability to take oxygen from the atmosphere and use it to produce energy for our muscle cells.

Kicking Ability

A kick is a skill in association football in which a player strikes the ball with their foot. Kicking is one of the most difficult skills to acquire in football. This skill is also vitally important, as kicking is the way in which passes are made and the primary means by which goals are scored.

Dribbling Ability

In soccer, dribbling refers to the maneuvering of a ball under the control of a single player in a given direction, whist avoiding defenders' attempts to prevent this occurring. A successful dribble will bring the ball past defenders legally and create opportunities to score.

Passing Ability

Passing is to move the ball quickly among teammates in order to keep it away from opponents and, ultimately, in order to put the ball into a position for a shot on goal.

Shooting Ability

Shooting is hitting the ball in an attempt to score a goal. It is usually done using the feet or head.

SIGNIFICANCE OF THE STUDY

This study can contribute to the sports training field in the below mentioned ways.

1. Findings of this investigation will help the coaches to categorize the suitable methods of training among the four different types such as unilateral and bilateral resistance and plyometric training to improve the fitness elements and striking variables of soccer players.
2. This study of a unilateral and bilateral training programme to improve fitness elements and soccer performance compared to a traditional bilateral training programme is significant because it combines current research on the beneficial effects of a specific training programme on physical performance with what current elite soccer players are doing in terms of training.
3. If the predictions are supported and a unilateral training programme is proved to be more effective in improving all physical variables, it might be used to train soccer players to achieve optimal performance on the field.
4. Fitness elements and striking variables alterations following training in the experimental groups would help in framing a training schedule for the soccer players.
5. This study may help the physical educators and coaches to prescribe scientific training programme.
6. The study's findings may add to the vast body of knowledge in the field of sports training.

Chapter II

REVIEW OF RELATED LITERATURE

A study of relevant and related literature is an essential step to get a full picture of what has been done and suggested with regard to the problem under study. Such a review brings about deeper insight and clear perspective or the overall field. The researcher has presented a brief review of the research articles published in relation to the present study.

The researcher finds out some of the review of literature which could be very supportive and strengthen this study. The reviews of the literature have been classified under the following headings:

1. Studies Pertaining to Unilateral Resistance Training
2. Studies Pertaining to Bilateral Resistance Training
3. Studies Pertaining to Unilateral Plyometric Training
4. Studies Pertaining to Bilateral Plyometric Training
5. Summary of the Literature

Studies Pertaining to Unilateral Resistance Training

Liao et al., (2021) compared the effect of unilateral and bilateral resistance training interventions on measures of athletic performance. Keywords related with unilateral, bilateral and performance was used to search in the Web of Science, Pubmed databases, and Google Scholar and ResearchGate™ websites. 6365 articles were initially identified, 14 met the inclusion criteria and were included in the final analysis, with overall article quality being deemed

moderate. The quantitative analysis comprised 392 subjects (aged: 16 to 26 years). Sub-group analysis showed that unilateral exercise resistance training resulted in a large effect in improving unilateral jump performance compared to bilateral training (ES = 0.89 [0.52, 1.26]). In contrast, bilateral exercise resistance training showed a small effect in improving bilateral strength compared to unilateral (ES = -0.43 [-0.71, -0.14]). Non-significant differences were found in improving unilateral strength (ES = 0.26 [-0.03, 0.55]), bilateral jump performance (ES = -0.04 [-0.31, 0.23]), change of direction (COD) (ES = 0.31 [-0.01, 0.63]) and speed (ES = -0.12 [-0.46, 0.21]) performance. Unilateral resistance training exercises should be chosen for improving unilateral jumping performance, and bilateral resistance training exercises should be chosen for improving bilateral strength performance.

Moran et al., (2021) evaluated the effects of BLE and ULE on horizontal movement performance. To qualify for inclusion in the meta-analysis, studies must have included a resistance training intervention that compared the effects of BLE and ULE on a measure of movement speed such as sprinting in healthy study participants. They used the inverse-variance random-effects model for meta-analyses. Effect sizes (standardized mean difference), calculated from measures of horizontally orientated performance, were represented by the standardized mean difference and presented alongside 95% confidence intervals (CI). Though both modalities were effective (BLE = 0.60 [95% CI 0.34, 0.87], $Z = 4.44$ [$p < 0.01$]; ULE = 0.57 [95% CI 0.24, 0.89], $Z = 3.44$

[$p = 0.0006$]), there was no difference between the effect of BLE and ULE on movement speed (0.17 [95% CI − 0.15, 0.50], $Z = 1.03$ [$p = 0.30$]). For BLE, combined strength and plyometric training had the largest effect size (0.88 [95% CI 0.40, 1.36]]) followed by plyometric training (0.55 [95% CI 0.09, 1.01]), with the lowest effect in strength training (0.42 [95% CI − 0.02, 0.86]). For ULE, the largest effect size for training type was in plyometric training (0.78 [95% CI 0.33, 1.24]) closely followed by combined (0.63 [95% CI 0.03, 1.24]) with strength (0.29 [95% CI − 0.42, 1.01]) having a substantially lower effect size. Both BLE and ULE are effective in enhancing horizontal movement performance. However, contrary to popular opinion, supported by the concept of training specificity, ULE was no more effective at achieving this than BLE.

Tseng et al., (2020) compared the effects of unilateral eccentric training (ET) and concentric training (CT) of the elbow flexors (EF) on maximal voluntary isometric contraction (MVC) strength and muscle damage of the contralateral untrained EF. Young men were placed into ET, CT, ipsilateral repeated bout (IL-RB), and contralateral repeated bout (CL-RB) groups (n = 12 per group). The ET and CT groups performed unilateral EF training consisting of five sets of six eccentric and concentric contractions, respectively, once a week for 5 wk by increasing the intensity from 10% to 100% of MVC, followed by 30 maximal eccentric contractions (30MaxEC) of the opposite EF 1 wk later. The IL-RB group performed two bouts of 30MaxEC separated by 2 wk using the nondominant arm, and CL-RB group performed two bouts of 30MaxEC with a

different arm for each bout in 1-wk apart. The MVC increased ($P < 0.05$) greater for the trained (19% ± 8%) and untrained (11% ± 5%) arms in ET when compared with those in CT (10% ± 6%, 5% ± 2%). The magnitude of changes in muscle damage markers was reduced by 71% ± 19% after the second than the first bout for IL-RB group, and by 48% ± 21% for CL-RB group. Eccentric training and CT attenuated the magnitude by 58% ± 25% and 13% ± 13%, respectively, and the protective effect of ET was greater ($P < 0.05$) than CL-RB, but smaller ($P < 0.05$) than IL-RB. These results showed that cross-education effect was stronger for ET than CT, and progressive ET produced greater contralateral muscle damage protective effect than a single eccentric exercise bout.

Hester et al., (2019) examined the effects of unilateral resistance training (RT) on maximal velocity parameters in the ipsilateral and contralateral legs in young and older males. Young ($n = 22$; age $= 21.55 \pm 2.23$ years) and older ($n = 20$; age $= 65.10 \pm 9.65$ years) males were assigned to training or control groups. Unilateral isokinetic RT of the knee extensors was performed for 4 weeks. Peak velocity and acceleration were identified during a dynamic maximal voluntary contraction before (PRE), at Week 2 (MID), and after Week 4 (POST) of RT. Age-independent increases in peak velocity (1.5%) and acceleration (4.5%) were demonstrated at POST for the trained leg. For the untrained leg, acceleration increased (4.3%) at POST similarly between training groups. These findings provide evidence for the high degree of neuromuscular plasticity,

regardless of age, during the early phase of RT, and the potential for cross education of acceleration.

Truax (2019) determined whether four weeks of unilateral resistance training with a mirror augmented the cross-education effect within the biceps brachii by assessing changes in maximal, isometric biceps strength, biceps activation and triceps antagonistic activation. Six healthy, non-strength trained adult participants were randomly assigned into the mirror training group (n = 3; age = 27 ± 5 yrs.) and the non-mirror training group (n = 3; age = 25 ± 3 yrs.). Maximal voluntary isometric contractions (MVICs) measured with a Dillon Strain gauge were used to assess changes in the trained and untrained biceps strength across five weekly assessments (ex. Pre-, Week 2, Week 3, Week 4, and Postassessment) throughout the four-week program. Surface electromyography (sEMG) was recorded during bicep MVICs on each arm using a Delsys TRIGNOTM wireless system to assess changes in biceps and triceps activation across the four-week program in the trained and untrained arms. Each week of the program contained three exercise sessions consisting of three working sets of ten repetitions of dumbbell curls for the right arm only. A One-way ANOVA was conducted for the trained and untrained arms between the mirror training group and non- iv mirror training group at .05 level to determine if there were any significant differences between biceps MVIC, biceps sEMG and triceps EMG from pre- to post-assessment. The means and standard deviations of each variable were calculated, and a qualitative analysis of the results was used to

compare the mirror and non-mirror groups. Further, biceps electrical efficiency was calculated to evaluate the contributions of neurological adaptations involved in the changes associated with MVIC both arms of the mirror and non-mirror group. There were no significant differences between the mirror group and non-mirror group in biceps MVIC, biceps sEMG, or triceps EMG in either the trained or untrained arms. This lack of significance may be attributed to the small sample size used in this study (n = 6). Mirror group biceps MVIC was shown to increase in the trained and untrained limbs by 5.2 kg (22% of initial strength) and 4.3 kg (24% of initial strength), respectively. Non-mirror group biceps MVIC was shown to increase in the trained and untrained limbs by 5.13 kg (19% of initial strength) and 4.5 kg (23% of initial strength), respectively. Mirror group trained and untrained biceps sEMG both shown increasing trends across the five weekly assessments, while the untrained arm of the non- mirror group showed an increasing trend from the pre-assessment to the week four. Non-mirror group trained biceps sEMG presented no trends in the trained arm and a steady increase from week three to post-assessment in the untrained arm. Training had no noticeable effects on triceps or antagonistic activation during biceps MVIC. Despite the limitations, this study affirmed that the biceps unilateral training paradigms used in this study may be effective in enhancing strength in the trained and untrained biceps within its sample. Further studies with greater sample sizes are needed to investigate the differences between mirror and non-mirror unilateral training on MVIC, and agonist and antagonist muscle activation.

Afsharnezhad et al., (2018) determine the effects of 8-weeks unilateral resistance training on strength, time to task failure, neuromuscular fatigue and synergist muscles co-activation in trained and contralateral untrained limbs. 20 healthy female students were randomly assigned to either a training or a control group. The experimental group performed unilateral resistance training on non-dominant elbow flexors, 3 days per week for 8 weeks. The surface electromyography signal that was recorded from elbow flexor muscles during submaximal and maximal voluntary contraction(MVC) of both trained and untrained limb, were computed as Root Mean Square(RMS), mean power frequency(MPF) and integrated electromyography (IEMG) data in pre and post test. The result indicated a significant increase in elbow flexor MVC and time to failure in submaximal isometric task in trained and contralateral untrained limb. There was a significant difference between groups in RMS and MPF of biceps brachii in trained and untrained limb. However, this differences were not significant for brachialis and triceps in contralateral limbs. Also, after resistance training, there is a significant difference in the IEMG ratio of the muscles among blocks of submaximal contraction in trained and untrained limb, indicating a tendency to alternation in synergistic muscles activity. Cross transfer effect of unilateral resistance training on time to task failure might be explained, at least partly by the mechanism of synergistic alternate activity pattern.

Hedayatpour et al., (2017) investigated whether unilateral resistance training can affect the ability of untrained homologous muscle in the

contralateral limb to maintain force output over a sustained contraction. Methods: Fifteen healthy subjects completed 12 weeks of resistance training consisting of 36 sessions, using the unilateral leg press exercise. Sustained isometric knee extension performed at 50% of maximal force until task failure on both the ipsilateral trained leg and contralateral untrained leg. Surface electromyography (EMG) signals were recorded from the trained and contralateral untrained quadriceps (vastus medialis, rectus femoris, and vastus lateralis). Results: Time to task failure of the contralateral untrained leg was significantly increased after 12 weeks of unilateral resistance training of the quadriceps can increase the ability of homologous muscle in the contralateral limb to maintain force output.

Manca et al., (2017) appraise current data on CE and determine its overall magnitude of effect. Five databases were searched from inception to December 2016. All randomized controlled trials focusing on unilateral resistance training were carefully checked by two reviewers who also assessed the eligibility of the identified trials and extracted data independently. The risk of bias was assessed using the Cochrane Risk-of-Bias tool. Thirty-one studies entered the meta-analysis. Data from 785 subjects were pooled and subgroup analyses by body region (upper/lower limb) and type of training (isometric/ concentric/ eccentric/ isotonic–dynamic) were performed. The pooled estimate of CE was a significant 11.9% contralateral increase (95% CI 9.1–14.8; $p < 0.00001$; upper limb: + 9.4%, $p < 0.00001$; lower limb: + 16.4%, $p < 0.00001$). Significant CE effects

were induced by isometric (8.2%; $p = 0.0003$), concentric (11.3%; $p < 0.00001$), eccentric (17.7%; $p = 0.003$) and isotonic–dynamic training (15.9%; $p < 0.00001$), although a high risk of bias was detected across the studies. Unilateral resistance training induces significant contraction type-dependent gains in the contralateral untrained limb. Methodological issues in the included studies are outlined to provide guidance for a reliable quantification of CE in future studies.

Colomer-Poveda et al., (2017) tested the effects of 4 weeks of unilateral low-load resistance training (LLRT), with and without blood flow restriction (BFR), on maximal voluntary contraction (MVC), muscle thickness, volitional wave (V wave), and Hoffmann reflex (H reflex) of the soleus muscle. Twenty-two males were randomly distributed into three groups: a control group (CTR; n = 8); a low-load blood flow restriction resistance training group (BFR-LLRT; n = 7), who were an inflatable cuff to occlude blood flow; and a low-load resistance training group without blood flow restriction (LLRT; n = 7). The training consisted of four sets of unilateral isometric LLRT (25% of MVC) three times a week over 4 weeks. MVC increased 33% ($P < 0.001$) and 22% ($P < 0.01$) in the trained leg of both BFR-LLRT and LLRT groups, respectively. The soleus thickness increased 9.5% ($P < 0.001$) and 6.5% ($P < 0.01$) in the trained leg of both BFR-LLRT and LLRT groups, respectively. However, neither MVC nor thickness changed in either of the legs tested in the CTR group (MVC −1 and −5%, and muscle thickness 1.9 and 1.2%, for the control and trained leg,

respectively). Moreover, V wave and H reflex did not change significantly in all the groups studied (V_{wave}/M_{wave} ratio −7.9 and −2.6%, and H_{max}/M_{max} ratio −3.8 and −4%, for the control and trained leg, respectively). Collectively, the present data suggest that in spite of the changes occurring in soleus strength and thickness, 4 weeks of low-load resistance training, with or without BFR, does not cause any change in neural drive or motoneuronal excitability.

Radnor, Lloyd and Oliver (2017) examined individual responses to different forms of resistance training on measures of jumping and sprinting performance in school-aged boys. Eighty boys were categorized into 2 maturity groups (pre- or post–peak height velocity [PHV]) and randomly assigned to a plyometric training, resistance training, combined training, or control group. Intervention groups participated in training twice weekly for 6 weeks, with measures of acceleration, maximal running velocity, squat jump height, and reactive strength index (RSI) collected preintervention and postintervention. In the pre-PHV cohort, plyometric training and combined training resulted in significantly more positive responders than the other 2 groups in both sprint variables (standardized residual values >1.96). In the post-PHV cohort, significantly more positive responders for acceleration and squat jump height resulted from traditional strength training and combined training groups, compared with other groups. Conversely, plyometric training and combined training resulted in a significantly greater number of positive responders than the other 2 groups for maximal velocity and RSI. Control participants rarely

demonstrated meaningful changes in performance over the 6-week period. Irrespective of maturation, it would seem that combined training provides the greatest opportunity for most individuals to make short-term improvements in jump and sprint performance. Taking maturation into account, our data show that a plyometric training stimulus is important for individuals in the pre-PHV stage of development, whether as a stand-alone method or in combination with traditional strength training, when attempting to improve jumping and sprinting ability. However, individuals in the post-PHV stage require a more specific training stimulus depending on the performance variable that is being targeted for improvement.

Beyer et al., (2016) assess the cross education of strength and changes in the underlying mechanisms (muscle size, activation, and hormonal response) after a 4-week unilateral resistance training (URT) program. A group of 9 untrained men completed a 4-week URT program on the dominant leg (DOM), whereas cross education was measured in the nondominant leg (NON); and were compared with a control group (n = 8, CON). Unilateral isometric force (PKF), leg press (LP) and leg extension (LE) strength, muscle size (by ultrasonography) and activation (by electromyography) of the rectus femoris and vastus lateralis, and the hormonal response (testosterone, growth hormone, insulin, and insulin-like growth factor-1) were tested pretraining and posttraining. Group × time interactions were present for PKF, LP, LE, and muscle size in DOM and for LP in NON. In all interactions, the URT group improved significantly better than

CON. There was a significant acute hormonal response to URT, but no chronic adaptation after the 4-week training program. Four weeks of URT resulted in an increase in strength and size of the trained musculature, and cross education of strength in the untrained musculature, which may occur without detectable changes in muscle size, activation, or the acute hormonal response.

Urbin et al., (2015) examined adaptations in force-generating capacity of severely paretic wrist extensors resulting from high intensity, dynamic contractions of the non-paretic wrist extensors. A secondary, exploratory aim was to probe neural adaptations in a subset of participants from each sample using a single-pulse, transcranial magnetic stimulation (TMS) protocol. Separate samples of neurologically intact controls (n = 7) and individuals ≥4 months post stroke (n = 6) underwent 16 sessions of training. Following training, one-repetition maximum of the untrained wrist extensors in the control group and active range of motion of the untrained, paretic wrist extensors in the stroke group were significantly increased. No changes in corticospinal excitability, intracortical inhibition, or interhemispheric inhibition were observed in control participants. Both stroke participants who underwent TMS testing, however, exhibited increased voluntary muscle activation following the intervention. In addition, motor-evoked potentials that were unobtainable prior to the intervention were readily elicited afterwards in a stroke participant. Results of this study demonstrate that high-intensity resistance training of a non-paretic upper extremity muscle group can enhance voluntary muscle activation and

force-generating capacity of a severely paretic muscle group after stroke. There is also preliminary evidence that corticospinal adaptations may accompany these gains.

Boone (2014) examined the effects of short-term lower body unilateral resistance training on hormonal, muscle morphological, and performance measures in young men. Seventeen healthy, untrained young men (Age: 22.8 ± 3.7 y; BMI: 26.5 ± 4.9 kg/m2) were randomly assigned to one of two groups (UT: 22.9 ± 4.6 y, 25.3 ± 4.2 kg/m2; CON: 24.0 ± 4.6 y, 27.7 ± 5.1 kg/m2). Resistance training consisted of 4 weeks of unilateral lower body and bilateral upper body exercises on 3 days per week. Each training session entailed unilateral countermovement jumps (3 × 8), unilateral leg press (LP), bilateral chest press (CP), unilateral leg extension (LE), and bilateral low row (LR). Strength exercises were performed for 3 sets of 8-10 repetitions; lower body exercises were performed with the dominant leg only. Muscle thickness (MT), pennation angle (PA), cross-sectional area (CSA), and echo-intensity (EI) of the vastus lateralis (VL) and rectus femoris (RF) muscles of both legs was assessed via ultrasound. Fascicle length (FL) was calculated as [MT / sin(PA)]. Maximal dynamic unilateral LP and LE strength was assessed during one-repetition maximum (1RM) testing; CP and LR 1RM strength was estimated as [repetition weight/(1.0278-0.0278) (reps)]. Maximal isometric knee extensor strength was isolaterally assessed via maximal voluntary contraction (MVC) testing. Mean and peak power output (Watts) was quantified during unilateral

countermovement jumps via accelerometry. Fasting concentrations of total testosterone and growth hormone were obtained at baseline (PRE), immediately post (IP), 30-minutes post (30P), and 60-minutes post (60P) during both testing exercise sessions (Pre and Post). Following the 4-week intervention, all participants' maximal dynamic and isometric strength, mean and peak power output, muscle morphology, and hormonal responses were reassessed. Performance, ultrasound, and area under the curve data were analyzed using ANCOVA to observe between-group comparisons while controlling for baseline (PRE) values. Endocrine data were analyzed using a two-way, mixedfactorial repeated-measures ANOVA. Participants in the UT group experienced significant strength improvements of the trained (28 to 150%) and untrained legs (12 to 160%). Training did not elicit significant improvements in maximal isometric strength or power output of the trained or untrained leg. The trained RF experienced significant increases in CSA and MT. The trained VL experienced a significant increase in CSA. Muscle size of the untrained leg was not significantly augmented. Training did not elicit changes in the acute hormonal response to exercise. Four weeks of unilateral lower body resistance training using the dominant leg appears sufficient to evoke strength gains of both the ipsilateral and contralateral legs. However, meaningful morphological changes were observed in the trained leg only. Differences in acute hormonal responses to resistance exercise did not appear to explain the observed differences. In addition, unilateral lower body resistance training did not appear

to augment the acute endocrine response to an acute bout of resistance exercise. Current findings suggest that the cross-educational strength transfer during the early stage of training is attributable to factors other than changes in muscle morphology and circulating hormones.

Tillin, Pain and Folland (2011) investigated the contribution of neural adaptations to strength changes after 4 weeks of unilateral isometric resistance training. Maximal and submaximal isometric knee extension contractions were assessed before and after training. Surface electromyography (EMG) data were collected from the agonist and antagonist muscles and normalized to evoked maximal M-wave and maximal knee flexor EMG, respectively. The interpolated twitch technique (ITT) was also used to determine activation at maximum voluntary force (MVF). MVF increased in the trained (+20%) and untrained (+8%) legs. Agonist EMG at MVF increased in the trained leg (+26%), although activation determined via the ITT was unchanged. In both legs the position of the force–agonist EMG relationship was unchanged, but antagonist coactivation was lower for all levels of agonist activation. Strength gains in the trained leg were due to enhanced agonist activation, whereas decreased coactivation may have affected strength changes in both legs.

Wilkinsonet al., (2006) aimed to gain insight into the role that the transitory increases in anabolic hormones play in muscle hypertrophy with unilateral resistance training. Ten healthy young male subjects (21.8 ± 0.4 years, 1.78 ± 0.04 m, 75.6 ± 2.9 kg; mean ± SE) engaged in unilateral resistance

training for 8 week (3 days/week). Exercises were knee extension and leg press performed at 80–90% of the subject's single repetition maximum (1RM). Blood samples were collected in the acute period before and after the first training bout and following the last training bout and analyzed for total testosterone, free-testosterone, luteinizing hormone, sex hormone binding globulin, growth hormone, cortisol, and insulin-like growth factor-1. Thigh muscle cross sectional area (CSA) and muscle fibre CSA by biopsy (*vastus lateralis*) were measured pre- and post-training. Acutely, no changes in systemic hormone concentrations were observed in the 90 min period following exercise and there was no influence of training on these results. Training-induced increases were observed in type IIx and IIa muscle fibre CSA of 22 ± 3 and 13 ± 2% (both $P < 0.001$). No changes were observed in fibre CSA in the untrained leg (all $P > 0.5$). Whole muscle CSA increased by 5.4 ± 0.9% in the trained leg ($P < 0.001$) and remained unchanged in the untrained leg ($P = 0.76$). Isotonic 1RM increased in the trained leg for leg press and for knee extension ($P < 0.001$). No changes were seen in the untrained leg. In conclusion, unilateral training induced local muscle hypertrophy only in the exercised limb, which occurred in the absence of changes in systemic hormones that ostensibly play a role in muscle hypertrophy.

Studies Pertaining to Bilateral Resistance Training

Moran et al., (2021) evaluated the effects of BLE and ULE on horizontal movement performance. To qualify for inclusion in the meta-analysis, studies must have included a resistance training intervention that compared the effects

of BLE and ULE on a measure of movement speed such as sprinting in healthy study participants. They used the inverse-variance random-effects model for meta-analyses. Effect sizes (standardised mean difference), calculated from measures of horizontally orientated performance, were represented by the standardised mean difference and presented alongside 95% confidence intervals (CI). Though both modalities were effective (BLE = 0.60 [95% CI 0.34, 0.87], $Z = 4.44$ [$p < 0.01$]; ULE = 0.57 [95% CI 0.24, 0.89], $Z = 3.44$ [$p = 0.0006$]), there was no difference between the effect of BLE and ULE on movement speed (0.17 [95% CI − 0.15, 0.50], $Z = 1.03$ [$p = 0.30$]). For BLE, combined strength and plyometric training had the largest effect size (0.88 [95% CI 0.40, 1.36]]) followed by plyometric training (0.55 [95% CI 0.09, 1.01]), with the lowest effect in strength training (0.42 [95% CI − 0.02, 0.86]). For ULE, the largest effect size for training type was in plyometric training (0.78 [95% CI 0.33, 1.24]) closely followed by combined (0.63 [95% CI 0.03, 1.24]) with strength (0.29 [95% CI − 0.42, 1.01]) having a substantially lower effect size. Both BLE and ULE are effective in enhancing horizontal movement performance. However, contrary to popular opinion, supported by the concept of training specificity, ULE was no more effective at achieving this than BLE.

Jacksteit et al., (2021) investigated the effectiveness of CPM compared to LLRT using the affected leg (CAMuni) and both legs (CAMbi) in the early post-operative rehabilitation. Hypotheses: (I) LLRT (CAMuni and CAMbi) is superior to CPM, (II) additional training of the unaffected leg (CAMbi) is more

effective than unilateral training (CAMuni). Eighty-five TKA patients were randomly assigned to three groups, respectively: (i) unilateral CPM of the operated leg; (ii) unilateral CAM of the operated leg (CAMuni); (iii) bilateral alternating CAM (CAMbi). Patients were assessed 1 day before TKA (pre-test), 1 day before discharge (post-test), and 3 months post-operatively (follow-up). Primary outcome: active knee flexion range of motion (ROM_{Flex}). Secondary outcomes: active knee extension ROM (ROM_{Ext}), swelling, pain, C-reactive protein, quality of life (Qol), physical activity, timed-up-and-go performance, stair-climbing performance, quadriceps muscle strength. Analyses of covariances were performed (modified intention-to-treat and per-protocol). Hypothesis I: Primary outcome: CAMbi resulted in a higher ROM_{Flex} of 9.0° (95%CI −18.03–0.04°, $d = 0.76$) and 6.3° (95%CI −14.31–0.99°, $d = 0.61$) compared to CPM at post-test and follow-up, respectively. Secondary outcomes: At post-test, C-reactive protein was lower in both CAM groups compared with CPM. Knee pain was lower in CAMuni compared to CPM. Improved ROM_{Ext}, reduced swelling, better stair-climbing and timed-up-and-go performance were observed for CAMbi compared to CPM. At follow-up, both CAM groups reported higher Qol and CAMbi showed a better timed-up-and-go performance. Hypothesis II: Primary outcome: CAMbi resulted in a higher knee ROM_{Flex} of 6.5° (95%CI −2.16–15.21°, $d = 0.56$) compared to CAMuni at post-test. Secondary outcomes: At post-test, improved ROM_{Ext}, reduced swelling, and better timed-up-and-go performance were observed in CAMbi compared to

CAMuni. Additional LLRT of the unaffected leg (CAMbi) seems to be more effective for recovery of function than training of the affected leg only (CAMuni), which may be mediated by positive transfer effects from the unaffected to the affected limb (cross education) and/or preserved neuromuscular function of the trained, unaffected leg.

Appleby, Cormack and Newton (2020) documented that maximal strength can be developed using bilateral or unilateral resistance training, the purpose of this study was to determine the magnitude of transfer of unilateral or bilateral resistance training to sprint and change of direction (COD) performance. Thirty-three trained participants (average training age = 5.4 ± 2.9 years and 1 repetition maximum [1RM] 90° squat = 177.6 ± 26.7 kg) completed either a bilateral group (BIL, *n* = 13), unilateral (UNI, *n* = 10), or comparison (COM, *n* = 10) 18-week randomized controlled training design. Training involved 2 lower-body, volume-load–matched resistance sessions per week (6–8 sets × 4–8 reps at 45–88% 1RM), differing only in the prescription of a bilateral (squat) or unilateral (step-up) resistance exercise. Strength was assessed through 1RM squat and step-up, in addition to 20-m sprint and a customized 50° COD test. The effect size statistic ± 90% confidence limit (ES ± CL) was calculated to examine the magnitude of difference within and between groups at each time point. BIL and UNI groups improved their trained and non-trained strength exercise with an unclear difference in adaptation of squat strength (ES = −0.34 + 0.55). Both groups improved 20-m sprint (ES: BIL = −0.38 ± 0.49 and UNI =

−0.31 ± 0.31); however, the difference between the groups was unclear (ES = 0.07 ± 0.58). Although both groups had meaningful improvements in COD performance, bilateral resistance training had a greater transfer to COD performance than unilateral resistance training (between-groups ES = 0.59 ± 0.64). Both bilateral and unilateral training improved maximal lower-body strength and sprint acceleration. However, the BIL group demonstrated superior improvements in COD performance. This finding potentially highlights the importance of targeting the underlying physiological stimulus that drives adaptation and not exercise selection based on movement specificity of the target performance.

Appleby, Cormack and Newton (2019) examined the development of lower-body strength using either bilateral or unilateral resistance training. Developmental rugby players (*n* = 33; mean training age = 5.4 ± 2.9 years; 1 repetition maximum [1RM] 90° squat = 178 ± 27 kg) completed an 18-week randomized controlled training design (bilateral group [BIL], *n* = 13; unilateral group [UNI], *n* = 10; comparison, *n* = 10). The 8-week training phase involved 2 lower-body, volume-load matched resistance sessions per week (6–8 sets × 4–8 reps at 45–88% 1RM), differing only in the prescription of a bilateral (back squat) or unilateral (step-up) resistance exercise. Maximum strength was assessed by a randomized order of 1RM back squat and step-up testing and analyzed for within- and between-group differences using effect sizes (ES ± 90% confidence limits [CL]). Both training groups showed practically important

improvements in their trained exercise (ES ± 90% CL: BIL = 0.67 ± 0.48; UNI = 0.74 ± 0.38) with transfer to their nontrained resistance exercise (BIL step-up = 0.27 ± 0.39: UNI squat = 0.42 ± 0.39). The difference between groups in adaptation of squat strength was unclear (BIL ES = −0.34 ± 0.55), while the UNI group showed an advantage in step-up training (ES = 0.41 ± 0.36). The results demonstrate that practically important increases in lower-body strength can be achieved using bilateral or unilateral resistance training and development of that strength may be expressed in the movement not trained, supporting the transfer of strength training between exercises of similar joint movements and muscles. Coaches may choose to incorporate unilateral strength training where the prescription of bilateral training may be inhibited.

Abu-Talip and Abdul-Kadir (2018) investigated the physiological responses of unilateral versus bilateral acute RT on heart rate (HR), blood pressure (BP) and rate of perceived exertion (RPE). Sixteen (n = 16) trained women with mean age of23.31 (SD = 1.35) years old went through a total body exercise session for each unilateral and bilateral protocols which both consisted of major muscles group for 80% 1RM, 10 repetitions to maximal effort for 3 sets. The results revealed that all variables examined including HR, systolic blood pressure (SBP), diastolic blood pressure (DBP) and RPE were statistically changed (p < .001) across the times. Apart from that, unilateral and bilateral RT imposed significantly different stimulus on SBP (p < .05).

Gonzalo-Skok et al., (2017) compared the effects of unilateral and bilateral resistance training on single-leg power output, between-limbs imbalance (BLI), bilateral deficit (BLD), change of direction (COD), and linear sprinting and jumping performance in young elite basketball players. Twenty-two young (U-16–U-19) male basketball players were randomly assigned either to an exclusive unilateral (UNI) (n = 11) or a bilateral (BIL) (n = 11) resistance-training group during a 6-wk period. Both groups training consisted of 3 unilateral or bilateral 90° back-squat sets. A post determined number of repetitions was set until power output dropped to <10% of maximum power (MP) output. In addition, both groups performed 2 sets of 5 unilateral or bilateral drop jumps and 2 sets of 5 unilateral or bilateral countermovement jumps (CMJ). Pre- and posttraining, performance was assessed by an incremental bilateral and unilateral squat-load test, a multiple-COD test (V-cut test), a 15-m-sprint test (7.5 + 7.5 m) with one 180° COD performed with both right (180° RCOD) and left (180° LCOD) legs, a 25-m-sprint test (5- and 15-m split time), and a CMJ test. Within-group analyses showed substantial improvements in 180° RCOD, bilateral and unilateral MP, 25-m-sprint test, and CMJ in both groups. Between-groups analyses showed substantially better results in 180° LCOD, MP with right and left legs, BLI, and BLD in UNI than in BIL. Both training programs substantially improved most of the physical-fitness tests, but only UNI reduced between-limbs asymmetry and achieved greater enhancements in actions that mostly required applying force unilaterally in basketball players.

Beurskens et al., (2015) randomized-controlled trial was conducted to investigate training-specific effects of resistance vs. balance training on MIF and BLD of the leg extensors in old adults. Subjects were randomly assigned to resistance training (n = 19), balance training (n = 14), or a control group (n = 20). Bilateral heavy-resistance training for the lower extremities was performed for 13 weeks (3 × / week) at 80% of the one repetition maximum. Balance training was conducted using predominately unilateral exercises on wobble boards, soft mats, and uneven surfaces for the same duration. Pre- and post-tests included uni- and bilateral measurements of maximal isometric leg extension force. At baseline, young subjects outperformed older adults in uni- and bilateral MIF (all $p < .001$; $d = 2.61–3.37$) and in measures of BLD ($p < .001$; $d = 2.04$). We also found significant increases in uni- and bilateral MIF after resistance training (all $p < .001$, $d = 1.8\text{-}5.7$) and balance training (all $p < .05$, $d = 1.3\text{-}3.2$). In addition, BLD decreased following resistance ($p < .001$, $d = 3.4$) and balance training ($p < .001$, $d = 2.6$). It can be concluded that both training regimens resulted in increased MIF and decreased BLD of the leg extensors (HRT-group more than BAL-group), almost reaching the levels of young adults.

Studies Pertaining to Unilateral Plyometric Training

Moran et al., (2021) determine the relative effect of VPT and HPT on both vertical and horizontal measures of physical performance. To qualify for inclusion in the meta-analysis, studies must have included a plyometric training intervention that compared jumps executed in a vertical direction [i.e.

countermovement jump (CMJ)] to jumps executed in a horizontal direction (i.e. standing horizontal jump). They used the inverse-variance random effects model for meta-analyses. Effect sizes, calculated from measures of horizontally or vertically orientated performance, were represented by the standardized mean difference and presented alongside 95% confidence intervals (CI). For between-group analysis on horizontal outcomes, there was a moderate, significant effect size (ES) in favour of HPT (0.65 [95% CI 0.12, 1.18], $Z = 2.41$ [$p = 0.02$]). For the analysis on vertical outcomes, there was a trivial, non-significant difference between VPT and HPT (-0.04 [95% CI -0.33, 0.24], $Z = 0.0.29$ [$p = 0.77$]). Within-group analysis showed HPT to be superior to VPT across horizontally- (1.05 [0.38, 1.72] vs. 0.84 [0.37, 1.31]) and vertically-orientated (0.74 [0.08, 1.40] vs. 0.72 [0.02, 1.43]) performance measures. For horizontally-orientated outcomes, single-factor moderator analyses showed that longer programmes (> 7 weeks), more sessions (> 12) and combined bilateral and unilateral training were most effective, favouring HPT in each case. In vertically orientated outcomes, these same variables showed only trivial differences between HBT and VBT. HPT is at least as effective as VPT at enhancing vertical performance but is superior at enhancing horizontal performance. This means that HPT might be a more efficient method for enhancing multi-vector performance for sport.

Drouzas et al., (2020) compared the effects of unilateral and bilateral plyometric training on strength, sprint performance and lower limb power. Sixty-eight preadolescent soccer athletes were randomly assigned to a unilateral

plyometric training group (n=23), a bilateral plyometric training group (n=23) and a control group (n=22). Both plyometric training groups trained with equal volumes of unilateral or bilateral exercises for 15 minutes in each session, at which time the control group performed soccer-specific drills. Plyometric exercises were executed twice weekly for 10 weeks during the competitive season. The following tests were performed before and after the intervention: single-leg and double-leg countermovement jump, squat jump, horizontal jumps in different directions, maximal isometric strength of quadriceps and hamstrings, sprint performance, agility and balance. Unilateral plyometric training resulted in greater improvements compared to the control group in the following variables: hamstrings strength (ES: 0.91, p=0.037), 5m sprint time (ES: 0.93, p=0.004), single-leg countermovement jump (ES: 0.90, p=0.006), single- and double-leg squat jump (ES: 0.87, p=0.030 and ES: 0.73, p=0.067, respectively) and single-leg hop performance (ES: 1.01, p=0.004). The only tests where there was an improvement of BPT compared with the CG were the single-leg and double leg SJ (ES: 0.76, p=0.026; ES: 0.70, p=0.050). Quadriceps strength, side hop test, double-leg horizontal jump test, flamingo balance test and modified agility T-test were equally improved in all three groups ($p<0.001$). In conclusion, unilateral lower-limb plyometric training is more effective in increasing muscle strength and power in preadolescent soccer players when compared to bilateral training or soccer training alone.

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Ahmad and Jain (2020) investigated the effects of lower body plyometric training in young Kashmiri female volleyball players According to the findings of current study, CVJ-L, CVJ-R, RBJ, SLJ, and T agility test performance increase from pre-test to post-test for both UP and BP, but there are no significant differences between groups. Significant interaction effects are observed for the CVJ-R, RBJ, and T agility test, indicating that from pre-test to post-test the UP has greater improvement than the CON, according to the line graphs. The CVJ and SJ do not differ among types of training or from pre-test to post-test. It can be concluded that both unilateral and bilateral training are effective on improving most of the performance outcomes, but one program is not significantly better than the other in improving the jump ability and agility performance. The results from the current study indicate the effectiveness of unilateral and bilateral plyometric training on lower body power. Increase in lower body power may potentially improve overall volleyball performance by enhancing the jump ability and agility performance.

Elnaggar et al., (2019) evaluated the subsequent effects of plyometric training on weight-bearing symmetry, muscle strength, and gait performance in children with unilateral cerebral palsy. Thirty-nine children with spastic hemiplegia (age 8-12 years) were randomly divided into either the PLYO group (*n*=19, received a 30-minute plyometric exercise program plus the traditional physical rehabilitation, twice/week for eight consecutive weeks) or Non-PLYO group (*n*=20, received the traditional physical rehabilitation only). The weight-bearing symmetry index (WB-SI), maximum isometric muscle strength (MIMS)

of quadriceps and hamstring muscles, and spatial-temporal gait parameters were assessed pre and post-intervention. From pre- to post-intervention, changes of WB-SI among PLYO and Non-PLYO groups did not differ significantly (*P*=.81; hindfoot and *P*=.23; forefoot). MIMS of quadriceps and hamstring muscles at 90° knee flexion (*P*=.008 and .013 respectively) increased significantly in PLYO compared to Non-PLYO group. Walking speed (*P*=.033), stride length (*P*=.002), and step time (*P*<.001) improved markedly in PLYO group more than in Non-PLYO group. The proportion of single leg support (*P*=.14) among PLYO and Non-PLYO groups did not differ significantly. Addition of plyometric exercises to the physical rehabilitation programs of children with unilateral CP could achieve greater improvement in muscles strength and walking performance, but not in WB-SI.

Bogdanis et al., (2019) compared the effects of unilateral and bilateral plyometric training on single- and double-leg jumping performance, maximal strength, and rate of force development (RFD). Fifteen moderately trained subjects were randomly assigned to either a unilateral (U, $n = 7$) or bilateral group (B, $n = 8$). Both groups performed maximal effort plyometric leg exercises 2 times per week for 6 weeks. The B group performed all exercises with both legs, whereas the U group performed half the repetitions with each leg, so that total exercise volume was the same. Jumping performance was assessed by countermovement jumps (CMJs) and drop jumps (DJs), whereas maximal isometric leg press strength and RFD were measured before and after training

for each leg separately and both legs together. Countermovement jump improvement with both legs was not significantly different between U (12.1 ± 7.2%) and B (11.0 ± 5.5%) groups. However, the sum of right- and left-leg CMJ only improved in the U group (19.0 ± 7.1%, $p < 0.001$) and was unchanged in the B group (3.4 ± 8.4%, $p = 0.80$). Maximal isometric leg press force with both legs was increased similarly between groups (B: 20.1 ± 6.5%, U: 19.9 ± 6.2%). However, the sum of right- and left-leg maximal force increased more in U compared with B group (23.8 ± 9.1% vs. 11.9 ± 6.2%, $p = 0.009$, respectively). Similarly, the sum of right- and left-leg $RFD_{0\text{-}50\ and}$ $RFD_{0\text{-}100}$ were improved only in the U group (34–36%, $p < 0.01$). Unilateral plyometric training was more effective at increasing both single- and double-leg jumping performance, isometric leg press maximal force, and RFD when compared with bilateral training.

Hernández et al., (2018) compared the effects of plyometric jump training (PJT), with (RG) and without (NRG) between-session drill randomization, on performance measures (i.e., jumping and sprinting abilities, change of direction speed, and technical performance) in youth male basketball players (age, 10.2 ± 1.7 years), assigned to either the NRG (n = 7), RG (n = 6), or control group (n = 6). Before and after the intervention, countermovement jump, 20-cm drop jump, 30-m sprint (with or without ball dribbling), and change-of-direction speed tests were completed. The PJT was applied twice per week for seven weeks. The only difference between PJT groups was the order of drill execution. An ANOVA was

used to detect differences between study groups. The analyses revealed significant main effects of time (all $p<.01$; $d = 0.64$-0.89) and group x time interaction (all $p<.05$; $d=0.31$-51) for all examined variables. Post hoc analyses revealed moderate-large significant improvements for the RG (countermovement jump: 18.8%, $d = 0.6$; 20-cm drop jump: 23.9%, $d = 0.80$; 30-m sprint: 11.6%, $d = 1.13$; 30-m sprint with ball dribbling: 9.3%, $d = 0.54$; change of direction speed test: 14.6%, $d = 1.82$). In contrast, post hoc analyses revealed only small improvements for the NRG (20-cm drop jump: 14.1%, $d = 0.36$; 30-m sprint: 6.8%, $d = 0.45$; 30-m sprint with ball dribbling: 8.8%, $d = 0.35$; change of direction speed test: 10.5%, $d = 0.49$). Application of PJT without randomization is effective for improving physical and technical qualities. However, PJT could be more beneficial when executed with between-session randomization of drills.

Ramírez-Campillo et al., (2018) compared the changes in young soccer player's fitness after traditional bilateral vs. unilateral combined plyometric and strength training. Male athletes were randomly divided in two groups; both received the same training, including strength training for knee extensors and flexors, in addition to horizontal plyometric training drills. The only difference between groups was the mode of drills technique: unilateral (UG; $n = 9$; age, 17.3 ± 1.1 years) vs. bilateral (TG; $n = 9$; age, 17.6 ± 0.5 years). One repetition maximum bilateral strength of knee muscle extensors (1RM_KE) and flexors (1RM_KF), change of direction ability (COD), horizontal and vertical jump

ability with one (unilateral) and two (bilateral) legs, and limb symmetry index were measured before and after an 8-week in-season intervention period. Some regular soccer drills were replaced by combination of plyometric and strength training drills. Magnitude-based inference statistics were used for between-group and within-group comparisons. Beneficial effects ($p < 0.05$) in 1RM_KE, COD, and several test of jumping performance were found in both groups in comparison to pre-test values. The limb symmetry index was not affected in either group. The beneficial changes in 1RM_KE (8.1%; $p = 0.074$) and 1RM_KF (6.7%; $p = 0.004$), COD (3.1%; $p = 0.149$), and bilateral jump performance (from 2.7% [$p = 0.535$] to 10.5% [$p = 0.002$]) were *possible* to *most likely* beneficial in the TG than in the UG. However, unilateral jump performance measures achieved *likely* to *most likely* beneficial changes in the UG compared to the TG (from 4.5% [$p = 0.090$] to 8.6% [$p = 0.018$]). The improvements in jumping ability were specific to the type of jump performed, with greater improvements in unilateral jump performance in the UG and bilateral jump performance in the TG. Therefore, bilateral strength and plyometric training should be complemented with unilateral drills, in order to maximize adaptations.

Isnaini (2017) determined the effect of training plyometric unilateral and bilateral program using the method and compare the training which is more effective to increase speed and explosive power of leg muscle. This research uses experimental, design using is matching only design. This study uses a population

of 45 individuals with a sample of the treated group I was 15 people with were given using the method unilateral, treatment group II was given 15 people with training method to bilateral and the control group 15 people without treatment but practicing basketball as usual done. The test used is run 30 meter to measure speed and vertical jump (jumpDF) to measure explosive power of leg muscle. The conclusion of this study training program using the method of plyometric unilateral and bilateral have increase significant effect on the speed and explosive power of leg muscle. To increase speed and explosive power of leg muscle, unilateral is more effective than a bilateral and a control group.

Potter (2017) examined the effects of a unilateral strength and plyometric program on power (bilateral and unilateral vertical jumps), speed (20 meter sprint), and agility (Agility T Test) in collegiate soccer players compared to a traditional bilateral-based training program. Due to the fact that a majority of the research on performance variables in athletes is done using bilateral lifting and plyometric programs, yet most movements in field sports such as sprinting and changing direction are unilateral-based, this specific topic could have value for enhanced performance for athletic populations. The participants included 34 male and female Division-I soccer players who were paired up and then randomly assigned to a six week unilateral-based or bilateral-based training program. Pre and post tests were conducted prior to and after the six week training, respectively. In relation to pretest results, athletes' bilateral vertical jump, unilateral vertical jump, 20 meter sprint, and T-Agility Test increased after

six week training. The test scores were significantly correlated. Multivariate analysis of covariance results showed that pretest covariates were significant predictors for the corresponding posttest outcome, yet there was not a significant difference between the unilateral and bilateral training group's improvements (Wilks' $\lambda = .88$, $F_{3,13} = .37$, $p = .86$). Athletes in the unilateral training group scored slightly better than those in the bilateral training group, yet not significantly.

Slimani et al., (2016) critically reviewed the available literature related to PT and its effects on physical fitness in team sport athletes. We also considered studies that combined PT with other popular training modalities (e.g. strength/sprint training). Generally, short-term PT (i.e. 2-3 sessions a week for 4-16 weeks) improves jump height, sprint and agility performances in team sport players. Literature shows that short PT (<8 weeks) has the potential to enhance a wide range of athletic performance (i.e. jumping, sprinting and agility) in children and young adult amateur players. Nevertheless, 6 to 7 weeks training appears to be too short to improve physical performance in elite male players. Available evidence suggests that short-term PT on non-rigid surfaces (i.e. aquatic, grass or sand-based PT) could elicit similar increases in jumping, sprinting and agility performances as traditional PT. Furthermore, the combination of various plyometric exercises and the bilateral and unilateral jumps could improve these performances more than the use of single plyometric drills or traditional PT. Thus, the present review shows a greater effect of PT

alone on jump and sprint (30 m sprint performance only) performances than the combination of PT with sprint/strength training. Although many issues related to PT remain to be resolved, the results presented in this review allow recommending the use of well-designed and sport-specific PT as a safe and effective training modality for improving jumping and sprint performance as well as agility in team sport athletes.

Ramírez-Campillo et al., (2015) compared the effects of bilateral, unilateral, or combined bilateral and unilateral plyometric training (PT) on muscle power output, endurance, and balance performance adaptations in young soccer players. Four groups of young soccer players (age 11.4 ± 2.2 years) were divided into control group (CG; $n = 14$), bilateral group (BG; $n = 12$), unilateral group (UG; $n = 16$), and bilateral + unilateral group (B + UG; $n = 12$). Players were measured in unilateral and bilateral countermovement jump with arms, 5 multiple bounds test, 20-cm drop jump reactive strength index, maximal kicking velocity, sprint and agility test time, endurance, and balance performance. The PT was applied during 6 weeks, 2 sessions per week, for a total of 2,160 jumps. After intervention, all PT groups showed a statistically significant ($p \leq 0.05$) change in all performance measures, with no statistically significant differences between treatments. Among the 21 performance measures, the B + UG showed a significantly ($p \leq 0.05$) higher performance change in 13 of them vs. the CG, whereas the UG and BG showed only 6 and 3, respectively. The current study showed that bilateral, unilateral, and combined bilateral and unilateral PT

ensured significant improvement in several muscular power and endurance performance measures in young soccer players. However, the combination of unilateral and bilateral drills seems more advantageous to induce superior performance improvements.

Johnson et al., (2014) evaluated the optimal duration and effects of plyometric training on the gross motor abilities of 3 boys with unilateral spastic cerebral palsy (9 years 11 months, 10 years, and 8 years 9 months). This was a multiple-baseline, multiple-probe, single-subject experiment. The intervention followed the National Strength and Conditioning Association's guidelines for youth. The Gross Motor Function Measure 66, 10×5-m sprint, 20-m run, throw ball, broad jump, and vertical jump tests were used to evaluate gross motor abilities, agility, running speed, and power. Improvements were found in upper extremity power, Gross Motor Function Measure 66 scores, and agility. Findings for lower extremity power and running speed were inconsistent. Training duration ranged from 8 to 14 weeks. This study suggests that plyometric training improves gross motor ability, agility, and upper extremity power in boys with unilateral cerebral palsy. Treatment duration should be determined by an individual's capacity, the task, and the outcome measure.

Váczi et al., (2013) investigated the effects of a short-term in-season plyometric training program on power, agility and knee extensor strength. Male soccer players from a third league team were assigned into an experimental and a control group. The experimental group, beside its regular soccer training

sessions, performed a periodized plyometric training program for six weeks. The program included two training sessions per week, and maximal intensity unilateral and bilateral plyometric exercises (total of 40 – 100 foot contacts/session) were executed. Controls participated only in the same soccer training routine, and did not perform plyometrics. Depth vertical jump height, agility (Illinois Agility Test, T Agility Test) and maximal voluntary isometric torque in knee extensors using Multicont II dynamometer were evaluated before and after the experiment. In the experimental group small but significant improvements were found in both agility tests, while depth jump height and isometric torque increments were greater. The control group did not improve in any of the measures. Results of the study indicate that plyometric training consisting of high impact unilateral and bilateral exercises induced remarkable improvements in lower extremity power and maximal knee extensor strength, and smaller improvements in soccer-specific agility. Therefore, it is concluded that short-term plyometric training should be incorporated in the in-season preparation of lower level players to improve specific performance in soccer.

Makaruk et al., (2011) examined the effects of unilateral and bilateral plyometric exercise on peak power and jumping performance during different stages of a 12-week training and detraining in women. Forty-nine untrained but physically active female college students were randomly assigned to 1 of 3 groups: unilateral plyometric group (n = 16), bilateral plyometric group (BLE; n = 18), and a control group (n = 15). Peak power and jumping ability

were assessed by means of the alternate leg tests (10-second Wingate test and 5 alternate leg bounds), bilateral leg test (countermovement jump [CMJ]) and unilateral leg test (unilateral CMJ). Performance indicators were measured pretraining, midtraining, posttraining, and detraining. Differences between dependent variables were assessed with a 3 × 4 (group × time) repeated analysis of variance with Tukey's post hoc test applied where appropriate. Effect size was calculated to determine the magnitude of significant differences between the researched parameters. Only the unilateral plyometric training produced significant ($p < 0.05$) improvement in all tests from pretraining to midtraining, but there was no significant ($p < 0.05$) increase in performance indicators from midtraining to posttraining. The BLE group significantly ($p < 0.05$) improved in all tests from pretraining to posttraining and did not significantly ($p > 0.05$) decrease power and jumping ability in all tests during detraining. These results suggest that unilateral plyometric exercises produce power and jumping performance during a shorter period when compared to bilateral plyometric exercises but achieved performance gains last longer after bilateral plyometric training. Practitioners should consider the inclusion of both unilateral and bilateral modes of plyometric exercise to elicit rapid improvements and guard against detraining.

Twist, Gleeson and Eston (2008) determined the effects of plyometric exercise on unilateral balance performance. Nine healthy adults performed baseline measurements on the dominant limb that consisted of: a 20-s unilateral

stability test on a tilt balance board, where a higher stability index represented deterioration in balance performance; isokinetic plantar flexion torque at 0.52 and 3.14 rad · s^{-1}; muscle soreness in the calf region; and resting plantar flexion angle. Plyometric exercise consisted of 200 counter-movement jumps designed to elicit symptoms of muscle damage, after which baseline measurements were repeated at 30 min, 24, 48, and 72 h. Perceived muscle soreness of the calf region increased significantly following the plyometric exercise protocol ($F_{4,32} = 17.24$, $P < 0.01$). Peak torque was significantly reduced after the plyometric exercise protocol ($F_{4,32} = 7.49$, $P < 0.05$), with greater loss of force at the lower angular velocity ($F_{4,32} = 3.46$, $P < 0.05$), while resting plantar flexion angle was not significantly altered compared with baseline values ($P > 0.05$). The stability index was significantly increased ($F_{4,32} = 3.10$, $P < 0.05$) above baseline (mean 2.3, s = 0.3) at 24 h (3.3, s = 0.4), after which values recovered. These results indicate that there is a latent impairment of balance performance following a bout of plyometric exercise, which has implications for both the use of skill-based activities and for increased injury risk following high-intensity plyometric training.

Studies Pertaining to Bilateral Plyometric Training

Lim et al., (2020) investigated the between-limb asymmetry in kinetic and temporal characteristics during bilateral plyometric drop jumps from different heights. Seventeen male basketball players performed drop jumps from 3 heights on two platforms in randomized orders. Vertical ground reaction force data were

analysed with respect to the lead limb (i.e. the limb stepping off the raised platform first) and trail limb. Peak forces and loading rates of each limb were calculated. The absolute time differential between the two limbs at initial ground contact and takeoff were determined. The frequency of symmetrical landing and taking off with "both limbs together" were counted using 3 time windows. Results showed that the lead limb displayed higher peak forces and loading rates than the trail limb across all heights ($p < .05$). As drop height increased, the absolute time differentials decreased at initial ground contact ($p < .001$) but increased at takeoff ($p = .035$). The greater the preset time window, the more landings and takeoffs were classified as bilaterally symmetrical. In conclusion, higher drop heights allowed subjects to become more bilaterally symmetrical in the timing of landing but this reduction in temporal asymmetry did not accompany with any reduction in kinetic asymmetry.

Greenwood, Kay and Baross (2020) investigated the effects of an 11-week unilateral versus bilateral plyometric training intervention on maximal isometric voluntary (MVC) knee extensor torque, countermovement jump height (CMJ), running economy (RE) and 3-km time trial (TT) performance. Twenty-seven recreationally trained endurance runners (12 females and 15 males) were randomly assigned to one of three groups: unilateral plyometric training (UPT; $n = 9$), bilateral plyometric training (BPT; $n = 9$) and control (CON; $n = 9$). RE, VO_{2max}, 3-km treadmill TT, isometric MVC (bilateral and unilateral) and CMJ (bilateral and unilateral) were measured prior to and after 11 weeks of

training (UPT and BPT; volume equated, 20-40 minutes, 2-3 days/week). Separate two-way repeated measures ANOVAs were used to assess within and between group differences in RE, VO_{2max}, 3-km TT, maximal isometric knee extensor torque and CMJ. Following 11 weeks of plyometric training there were significant improvements in RE (UPT 5.6%; BPT 4.9%, $p < 0.01$) and 3-km TT performance (UPT 2.4%; BPT 2.5%, $p < 0.01$) in addition to CMJ (UPT 12.5%; BPT 14.5%, $p < 0.01$) and maximal isometric knee extensor torque in the unilateral group (14.0%, $p < 0.01$). No significant differences in VO_{2max} or anthropometric measures were detected ($p > 0.05$). No statistically significant differences between training interventions ($p > 0.05$) were detected in any measure. These data demonstrate that UPT and BPT result in similar improvements in RE and 3-km TT run performance in recreational distance runners.

Singh et al., (2019) determined the effect of the sprint specific plyometric training on electromyography (EMG) changes in sprinters. Methodology: 40 university sprinters volunteered and were randomly assigned into two groups, group 1 (G1; n=20) sprint specific plyometric training group (mean age 18.65±0.875; mean height 164.10±11.30 cm; mean mass 59.20±10.74 kg) and group 2 (G2; n= 20) control group (mean age 18.95±1.19; mean height 166.60±9.80 cm; mean mass 61.60±9.24 kg). Both sprint specific plyometric training group and control group were assessed for neuromuscular activity of lower limb muscles by telemetric Noraxon TELEMYO U.S.A., Inc.v3.1.10

machine. Subjects in training group performed six weeks sprint specific plyometric protocol thrice a week. The EMG activities in the tibialis anterior (TA), vastus lateralis (VL), rectus femoris (RF), medial gastrocnemius (MG) and semitendinosis muscle (ST) were assessed pre and post training. The results showed significant changes ($p<0.05$) in the EMG activities for the mean amplitude of RF(rt), MG(lt), ST(rt) muscles and maximum periods of TA(rt), VL(rt), MG(lt) and ST(rt) muscles. Conclusion: The study demonstrates that the neuromuscular training program can increase the muscle recruitment to perform high intensity activities hence, can be recommended to coaches for athletes or individual.

Stewart et al., (2019) quantified the peak vertical ground reaction force (VGRF), impulse, and average and instantaneous loading rates developed during bilateral plyometric exercises. Fourteen collegiate male athletes performed four different bilateral plyometric exercises within a single testing session. Depth jumps from thirty, sixty and ninety centimeter heights (DJ30, DJ60, and DJ90, respectively), and a two consecutive jump exercise (2CJ), were randomly performed. The subjects landed on and propelled themselves off two force platforms embedded into the floor. The stance phase of each plyometric movement was analyzed for vertical force characteristics. The dependent variables were normalized to body weight. One-way repeated-measures ANOVA revealed significant differences between exercises ($p \leq 0.05$). For VGRF, only the DJ60 and 2CJ exercises were not different from

each other. The impulses between DJ60 and DJ90, and DJ30 and 2CJ, were not different. All exercises were different from each other in regards to average and instantaneous loading rate except for DJ30 vs. DJ60, and DJ90 vs. 2CJ. The DJ90 condition reported the highest peak VGRF by approaching five times body weight. The 2CJ condition had similar impulse and loading rates as the DJ90 condition. CONCLUSIONS: A proper progression and detailed program planning should be utilized when implementing plyometric exercises due to their different impact kinetics and how they might influence the body upon ground contact.

Wertheimer, Antekolovic and Matkovic (2018) analyzed the long-term effects of an eight-week plyometric training programme on land and in water on muscle damage indicators (lactate dehydrogenase (LDH), creatine kinase (CK) and serum urea (SU)), two experimental groups of physically active men (a group on land (EG1) and a group in water (EG2)) were tested before and after the first and the last plyometric training to monitor muscle damage indicators and adaptations. The results showed changes in CK activity after both plyometric trainings for EG1 and only after the first training for EG2. Moreover, after the eight-week programme, significant difference was observed in CK activity in comparison with EG2. There were no observed changes in LDH activity while SU showed greater changes for the group on land. The plyometric training programme in water resulted in smaller levels of muscle damage indicators. Although both experimental groups conducted the same plyometric training with

the same jump volume, the eccentric and concentric loads were not the same, so it can be concluded that adaptations in muscle damage processes are faster with smaller eccentric loads.

Kong (2018) examined the effects of 8-week unilateral and bilateral plyometric training program on jump ability and agility performance of young female volleyball players. Secondary school female volleyball players (N= 62, age= 14.56 Â±1.45 years, height= 159.14 Â±6.57 cm, weight= 53.55 Â±9.03 kg) were randomized and divided into three groups: the unilateral plyometric training group (UP), the bilateral plyometric training group (BP), and the control group (CON). For the UP and BP, the subjects completed 15 unilateral or bilateral plyometric training sessions over 8 weeks in addition to the regular volleyball training. For the CON, the subjects performed the regular volleyball training only. Pre-test and post-test were performed by all subjects before and after the intervention. The jump ability and agility performance were assessed by countermovement vertical jump (CVJ: double legs, right leg, and left leg), squat jump (SJ), 5 repeated block jumps (RBJ), standing long jump (SLJ), and T agility test. 2-way ANOVAs with repeated measures (3 groups x 2 times) were used to analyze the data. The results indicated that CVJ (right leg and left leg), RBJ, SLJ, and T agility test performance significantly increased (p<. 05) after 8 weeks for both unilateral and bilateral training, but there were no differences (p>. 05) between groups. Interaction effects (p<. 05) existed for the CVJ (right leg), RBJ, and T agility test, indicating that from pre-test to post-test the UP had

greater improvement than the CON. The CVJ (double legs) and SJ did not differ (p>. 05) among types of training or from pre-test to post-test. It can be concluded that both unilateral and bilateral training are effective on improving most of the performance outcomes, but one program is not significantly better than the other in improving the jump ability and agility performance.

Ramírez-Campillo et al., (2015) compared the effects of progressive volume-based overload to constant volume-based overload on muscle explosive and endurance performance adaptations during a bi-weekly short-term (i.e. six weeks) plyometric training intervention in young soccer players. Three groups of young soccer players (age 13.0 ± 2.3 y) were divided into: control (CG; n = 8), plyometric training with (PPT; n = 8) and without (NPPT; n = 8) a progressive increase in volume (i.e. 16 jumps per leg/week, with an initial volume of 80 jumps per leg each session). Bilateral and unilateral horizontal and vertical countermovement jump with arms (CMJA), 20 cm drop jump reactive strength index (RSI20), maximal kicking velocity (MKV), 10-m sprint, change of direction speed (CODS) and Yo-Yo intermittent recovery level 1 test (Yo-Yo IR1) were measured. Although both experimental groups significantly increased CMJA, RSI20, CODS and endurance performance, only PPT showed a significant improvement in MKV and 10-m sprint time. In addition, only PPT showed a significantly higher performance improvement in jumping, MKV and Yo-Yo IR1 compared to CG. Also, PPT showed higher meaningful improvement compared to NPPT in all (except one) jump performance measures. Furthermore,

although PPT involved a higher total volume compared to NPPT, training efficiency (i.e. percentage change in performance/total jump volume) was similar between groups. Our results show that PPT and NPPT ensured significant improvement in muscle explosive and endurance performance measures. However, a progressive increase in plyometric training volume seems more advantageous to induce soccer-specific performance improvements.

Mudlo (2014) compared two lower body, unilateral and bilateral, training styles on the development of athletic performance variables. Twenty-one division two collegiate swimmers (age 20.38 ± S.D.1.3), who were split into two groups, completed the training program. An eight week training program that utilized a modified single leg squat (MSLS) and unilateral plyometrics (n=11) or a bilateral back squat (BBS) and bilateral plyometrics (n=10) was used to train the athletes. The volume of training was equal across groups. Pre-post test assessments included a 5RM squat test, bilateral and unilateral jump height, a T-test, and goniometry, as differences were assessed. Significance was found after comparing the 5RM squat posttest (p=.043) and hip extension as measured by goniometry (p=.036) with the BBS group performing better when evaluated relative to the MSLS group. No significant differences were found in any of the other variables.

Wallace et al., (2010) quantify the vertical ground reaction forces (VGRFs) developed during the performance of popular bilateral plyometric movements. Fourteen power-oriented track and field men of collegiate and

national level randomly performed 3 trials of 9 different bilateral plyometric exercises in a single testing session. Three depth drop (DD) and 3 depth jump (DJ) conditions from 30, 60, and 90 cm heights (DD30, DD60, and DD90 and DJ30, DJ60, and DJ90) were tested, in addition to vertical jump (VJ), standing long jump (SLJ), and 2 consecutive jump (2CJ) conditions. Peak impact VGRFs were normalized to body weight. Additionally, all conditions were compared against the VJ in an intensity index. The SLJ condition resulted in a significantly higher peak VGRF than the 2CJ condition ($p \leq 0.05$). 90DD, 90DJ, 60DD, and SLJ had a significantly greater peak VGRF (5.39, 4.93, 4.30, and 4.22 times body weight, respectively) than the VJ condition (3.34 times body weight). The 30DJ condition had an insignificantly smaller peak VGRF (2.78 times body weight) when compared with the VJ. Practitioners may use these findings to more effectively progress athletes in these movements based on their intensities.

Summary of the Literature

All the research studies were presented in this section prove that unilateral and bilateral resistance and plyometric training produced better results on fitness elements of soccer players. The review of literature helped the researcher from the methodological point of view too. It was learnt that most of the research studies cited in this chapter are appropriate methods for developing fitness and sports performance. The present study may serve as a foundation and main ingredient for future research and investigation in different training methods for enhancing the fitness elements and striking variables.

Most strength training studies in the literature are conducted only physical and physiological measures of athletes and soccer players. Therefore, the mechanism(s) behind the increases in fitness elements and striking variables due to twelve weeks of unilateral and bilateral resistance and plyometric training have really been the subject of conjecture. There are only few studies in the literature that have actually measured the fitness elements and striking variables due to unilateral and bilateral resistance and plyometric training.

The results of the previous studies have shown that fitness parameters can be improved as a result of unilateral and bilateral resistance and plyometric training. Therefore, it is possible that unilateral and bilateral resistance and plyometric training can influence soccer striking variables as well. It is important to investigate the effects of unilateral and bilateral resistance and plyometric training to better understand and the potential benefits that it may have on the fitness elements and striking variables of soccer players.

In this chapter, the researcher had given research abstracts, which has been conducted recently and published through magazines, journals and periodicals pertaining to the topic considered in this study. These reviews of related literature helped the researcher for the better understanding of the problem and to interpret the result.

CHAPTER III

METHODOLOGY

In this chapter, the selection of subjects, variables and tests, orientation of testers and subjects, reliability of data, pilot study and training protocol, administration of various tests, collection of data, experimental design used and statistical technique applied are presented in detail.

SELECTION OF THE SUBJECTS

The aim of this study was to find out the impact of unilateral and bilateral resistance and plyometric training on selected fitness elements and striking variables among Soccer players. The study was delimited to 75 soccer players of age between eighteen and twenty one years and they were selected from the Mohammed Sathak AJ Engineering College, Siruseri, Chennai and Hindustan College of Arts and Science, Padur, Chennai. Participants were randomly assigned to four different training groups and one control group (15 in each group). Group-I performed Unilateral Resistance Training [URT], group-II performed Unilateral plyometric training[UPT], group-III performed Bilateral Resistance Training [BRT], group-IV performed Bilateral plyometric Training [BPT] and group-V [CG] was control. The chosen participants were medically inspected by a experienced physician and certified that they were physically healthy to undergo the specific training. The consent form for the proposed research study was collected from the participants and the copy of a consent form is enclosed

in the appendix -I. The mean and standard deviation values on age, height and weight of the experimental and control groups participants are presented below.

Table – 3.1
Physical Characteristics of the Participants

Group	Number	Age (years)	Height (cm)	Weight (kg)
Unilateral Resistance Training [URT]	15	19.42±1.65	167.23± 4.67	65.82± 4.68
Unilateral Plyometric Training[UPT]	15	20.05±1.73	169.05±2.94	68.19±3.73
Bilateral Resistance Training [BRT]	15	19.23±1.91	171.62±3.16	67.58±5.14
Bilateral plyometric Training [BPT]	15	20.65±1.23	173.02±3.74	70.09±3.84
Control group [CG]	15	21.57±1.43	170.59±4.19	69.45±4.16

SELECTION OF VARIABLES

Before choosing variables, the researcher reviewed the existing literature and spoke with a number of experts as well as his guide. Before finalising the variables, the availability of technology for the purpose of analysis, practicality, reliability procedure, and the outcome were all carefully considered. The following are the study's chosen independent and dependent variables.

Independent Variables

Since resistance training is inherently linked to our bodies, there are a lot of medical terms and fancy terms involved with resistance training. There are two different types of resistance training exercises, unilateral or one-sided and bilateral or two-sided. Aside from the obvious, “we get strong by training our muscles” understanding the complexities of resistance training helps us to create a balanced, impactful workout routine.

When it comes to plyometric training, we may automatically think of traditional bilateral exercises like which use both arms and both legs simultaneously. While these bilateral exercises have been effective in improving strength and power, there is increasing interest in the benefits of unilateral exercises, those that use only one arm or leg at a time to improve athletic performance. Unilateral exercises are typically used as assistance exercises to bilateral exercises to add volume or variation within a strength and power program. Given that many sport-specific movements are unilateral in nature, many argue that unilateral resistance and plyometric training provides a more specific and transferable stimulus to sport performance. Sprinting, jumping, and changing direction are all performed unilaterally, so training in a predominately unilateral manner may provide greater specificity and ultimately provide better transfer from training to competition given the similarity of the movement patterns. There have been many studies investigating the effects of both bilateral and unilateral training and determining which is best for improving speed and power. However, limited studies were performed to determine the relative effect of unilateral and bilateral resistance and plyometric training on selected fitness elements and striking variables among Soccer players. In this experimental study four experimental groups were selected.

1. Experimental Group-I – Unilateral Resistance Training Group [URTG]
2. Experimental Group-II – Unilateral Plyometric Training Group [UPTG]
3. Experimental Group-III - Bilateral Resistance Training Group [BRTG]

4. Experimental Group-IV - Bilateral Plyometric Training Group [BPTG]

5. Group-V - Control Group [CG]

Dependent Variables

In recent years, football success has been shown to be highly dependent on various physical, technical, tactical, and psychological factors (Dragijsky et al., 2017; Barrett et al., 2018; Botek, Krejcí & Weisser, 2014). Bangsbo (1994) emphasized that for successful competitiveness, the development of speed, agility, strength with combination of aerobic and anaerobic (even maximal) abilities is important for successful, competitive football careers. Recent investigations (Al-Haddad et al., 2015; Boone et al., 2012) and an earlier study conducted by Matković et al., (2003) emphasized that age, morphology, and physical fitness were influential parameters of football performance in elite-level football players, Although these data are valuable, evidence at the youth level is considerably lacking, especially at a competitive level. Investigating how physical fitness parameters have a profound influence on their daily training and future performance.

The central goal of strength/power training in a highly competitive sport is to improve the players' specific and relevant athletic activities inherent in their sport. To achieve this outcome, different strength/power training modes have been adopted with the final end point of achieving an improvement in players' performance in relevant motor tasks (e.g., jumping, sprinting, and changing direction). Certain training methods combine different exercise modes (e.g.,

weight training, plyometric training, and sport-specific force-based actions) and allow for optimal power development and transfer to athletic activities due to both the neural and morphological adaptations typically associated with advanced training. In fact, the intrinsic characteristics of soccer activity patterns (a varied range of motor actions that involve both breaking and propulsive forces as well as distinct contraction modes and velocities that require the all force-velocity potential of the neuromuscular system) that highlight the importance of the principle of specificity in strength and muscle power training cannot be understated. The unilateral and bilateral resistance and plyometric training therefore, assume high importance in soccer. The following selected fitness elements and striking variables were selected for this study.

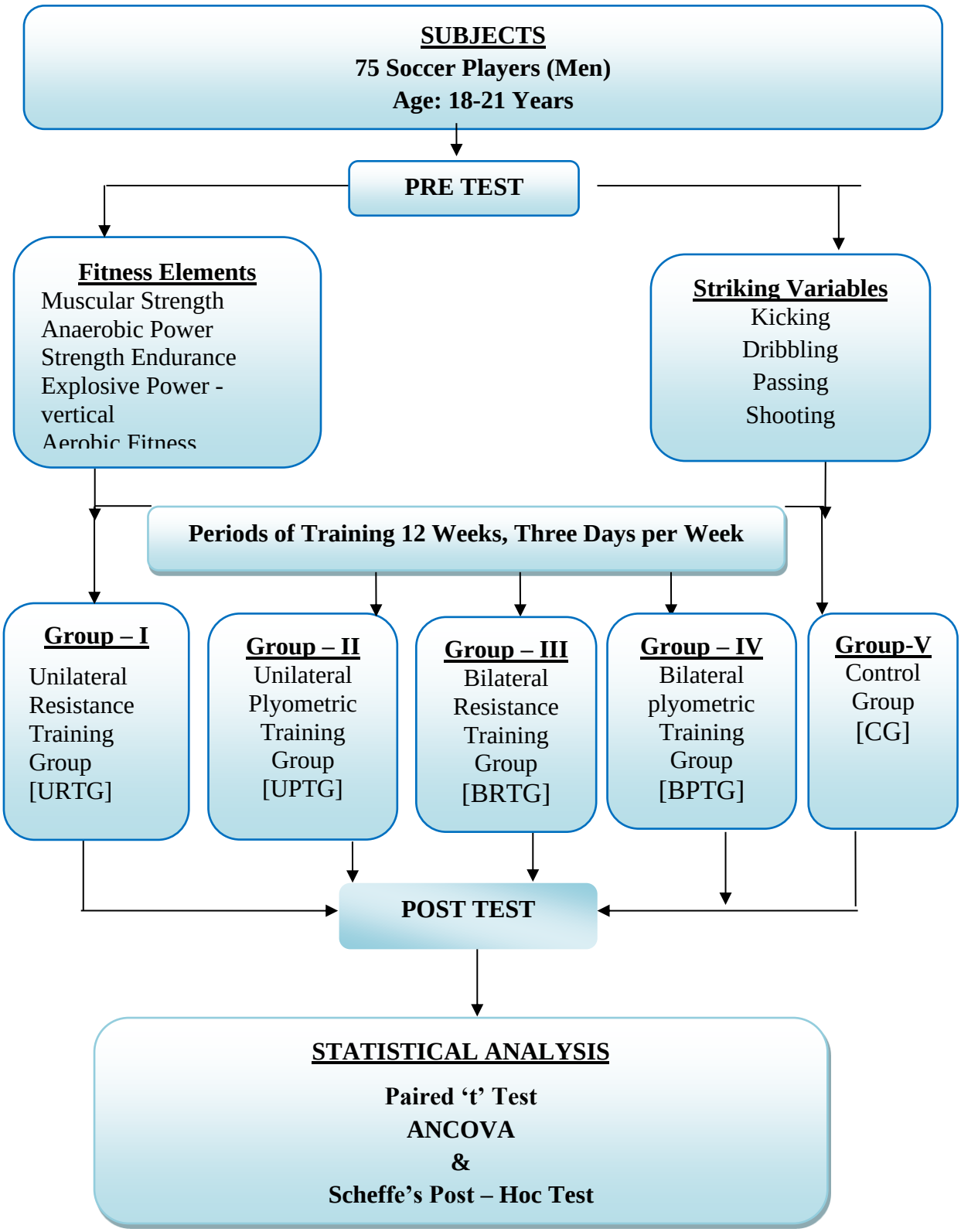
This study was delimited to the Fitness Elements and tests such as Muscular Strength [I RM Test], Anaerobic Power [RAST], Abdominal Strength Endurance [Sit ups], Explosive Power - Vertical [Sergeant Jump]. This study was also delimited to the Striking Variables and Tests such as Kicking [Mor MC Donald Soccer test], Dribbling [Mor-Christian dribbling Test], Passing [Mor-Christian Passing Test] and Shooting abilities, [Mor-Christian Shooting Test].

RESEARCH DESIGN

The research design used was Purposive random group design with unilateral and bilateral resistance and plyometric training as independent variables and selected fitness elements and striking variables as dependent variables. The methodology followed is given in chart-I as research flowchart.

Chart – I

FLOW CHART DEPICTING THE METHODOLOGY FOLLOWED IN THIS STUDY



SELECTION OF TESTS

The investigator reviewed the literature, consulted with physical education specialists, and chose test items to gather data on the specified fitness characteristics and striking variables, which were standardized and most appropriate for this study, as shown in table 3.2.

Table – 3.2

Selection of Tests

S. No.	Variables	Test Items	Measurement Unit
1	Muscular strength	I RM Test	Kg
2	Anaerobic power	RAST	Watts
3	Strength endurance	Bent knee sit-ups	Number
4	Explosive power (Vertical)	Jump and reach test	Centimeters
5	Aerobic fitness	Footeval Test	Number
6	Kicking	MC Donald Soccer test	Points
7	Dribbling	Mor-Christian General Soccer Ability Skill Test battery	Seconds
8	Passing		Points
9	Shooting		Points

ORIENTATION OF TESTERS

The investigator briefly discussed and showed the study's purpose, testing procedures, and scoring process to the testers who assisted him. The investigator was assisted by two physical education teachers. They were fully informed about the study's goal and the data needed for it. The investigator demonstrated how the various equipment’s utilized in this investigation worked. The helpers were also shown how to measure the identified dependent variables precisely. The

testers were taught how to conduct tests and collect data without making any mistakes.

ORIENTATION TO THE SUBJECTS

The subjects were first given instructions on how to conduct the tests, and then the investigator demonstrated each test item. Each individual was given as many trials as they needed to become familiar with the test items.

RELIABILITY OF THE DATA

The reliability of data was ensured by establishing the instrument reliability, tester's competency, subject's reliability and reliability of the tests.

Instrument Reliability

The instruments required were in good functioning order. The instruments were obtained from reputable and well-known suppliers. Their calibrations were put to the test and determined to be accurate enough for the study's purposes.

Tester's Competency

With the help of physical education teachers, the investigator gathered data. The testers were given an explanation and demonstration of the study's purpose and testing procedures. The investigator had several practice sessions to familiarize himself with the proper testing procedure. The test and re-test procedure was used to determine the testers' reliability. Because of the excellent correlation, the tester's ability to take measurements and test dependability was acknowledged.

Subject Reliability

The test, re-test scores indicated the subject reliability as the same subjects were used under various conditions by the tester.

Reliability of Tests

The tester's capacity to administer tests was evolved with the test's reliability. The test and retest approach was used to measure test reliability. For this aim, ten participants were chosen at random and employed in this study as test subjects. At a five-day interval, all of the chosen criterion variables were assessed twice for the same subjects under identical settings. Univariate correlation (intra class correlation) was estimated independently for each criteria variable, as suggested by Johnson and Nelson (1988). The obtained correlation coefficient is shown in table 3.3.

Table – 3.3

Intra Class Co-Efficient of Correlation on Selected Dependent Variables

S. No.	Dependent Variables	'R' Value
1	Muscular strength	0.94*
2	Anaerobic power	0.88*
3	Strength endurance	0.91*
4	Explosive power (Vertical)	0.96*
5	Aerobic fitness	0.93*
6	Kicking	0.85
7	Dribbling	0.90*
8	Passing	0.87*
9	Shooting	0.85*

**Significant (0.05 level)*
(Require Table value is0.77)

Since the derived ‘r’ values were much higher than the required value, the data were accepted as reliable in terms of instrument, tester and the subjects.

PILOT STUDY

A pilot study was undertaken before building the training schedule to determine the competence of all participants in order to fix the load. Twenty people were chosen at random and randomly allocated to one of four training groups: unilateral resistance training (URT), bilateral resistance training (BRT), unilateral plyometric training (UPT), and bilateral plyometric training (BPT). During this time, the tester had become aware of the problems and had educated himself with the methods. Following the pilot study, required adjustments were made in the areas of resistance and plyometric training activities, intensities, sets, and repetitions in conjunction with the guide. The main principles of sports training, such as progression, overload, and specificity, were followed when creating the training programmes.

TRAINING PROGRAMME

Sufficient warm up was given prior to the unilateral and bilateral resistance and plyometric training to all the subjects. The four chosen experimental groups were trained in the morning session, 3days a week for 12weeks. The experimental group-I performed unilateral resistance training (URT), group-II performed unilateral plyometric training (UPT), group-III performed bilateral resistance training (BRT), group-IV performed bilateral plyometric training (BPT) and group-V was control (CG). The unilateral and

bilateral resistance and plyometric training groups participated in a 12-week training program performing a variety of exercises designed for the upper and lower extremity.

Before commencement of 12-week treatment and the preliminary measurement, subjects of the training groups performed the specific training for four training sessions in two weeks (familiarization training sessions). The goal of these 2-week training (familiarization sessions) was to make known the soccer players with the chosen exercises used in the training. After familiarization sessions and pre testing, the soccer players took part in 12-week unilateral and bilateral resistance and plyometric training program with three training sessions per week. More specifically, these resistances as well as plyometric training sessions in unilateral and bilateral variations was performed after standardized warm-up for 10-minute, which includes three minutes of easy jogging, dynamic stretching as well as soccer drills. Finally, during the final part of the training, all three groups subjects were performed cool-down with jogging and penalty shots for 5-minutes.

Unilateral and Bilateral Resistance Training Protocol

The experimental group-I performed unilateral resistance training (URT) exercises and group-III performed bilateral resistance training (BRT) exercises. Training volume for the unilateral resistance training (URT) and bilateral resistance training (BRT) was equalized, with the BRT group performing resistance exercises with support on both limbs (arms or legs), while the URT

group performed 50% on each limbs (arms or legs) separately. The only training aspect to differ between the 2 groups was the allocation of bilateral or unilateral resistance training, at individually prescribed loads as a percentage of 1RM obtained at baseline and mid-testing. All exercise sets were performed under the guidance of coaches to assist with load prescription, performance monitoring, and technical execution.

The resistance training program was a total body workout consisting of 3 sets of 4-14 repetitions on 6 exercises that trained all the major muscle groups. The load was fixed for the experimental groups based on one repetition maximum (1 RM) of each participant in all the selected resistance exercises. The intensity of exercise performed for each exercise was progressively increased once in two weeks. The rest interval of 1:1 between exercises and 1:3 minutes between sets was given. The training schedules for the unilateral and bilateral resistance training groups are given in the appendix-II and IV.

Unilateral and Bilateral Plyometric Training Intervention

The participants in unilateral and bilateral plyometric training groups (group-II & IV) trained for 12 consecutive weeks with three training sessions per week. During this 12-week treatment period, the training load of plyometric drills were increased gradually, in terms of level of difficulty, as well as the total number of foot conducts. Additionally, the total volume of training (plyometric) sessions were increased gradually over two weeks by 20 foot-contacts.

During all of these training sessions, a suitable warm-up was given (3 minutes of joining, dynamic type stretching &soccer drills). Total training volume for the unilateral plyometric (UPT) and bilateral plyometric (BPT) groups were equalized, with the BPT group participants performed all exercises with both legs support, whilst the UPT group participants performed 50% of the exercise on each leg separately. All these plyometric training sessions were done with their utmost effort. Total training volume ranged from 90 to 140 foot contacts. Ample recovery was given based on work rest ratio between exercises (1:1), sets (1:3) and sessions (one day). The training schedules for the unilateral and bilateral plyometric training groups are given in the appendix-III and V.

ADMINISTRATION OF THE TESTS

The specified fitness factors and striking variables were measured using standardized assessments. This sections clarify the test objectives, descriptions, and scoring.

Leg Press

Purpose: To measure the leg strength of the subjects

Equipments: Multi-gym.

Procedure: The participants were instructed to sit on the machine with their legs under it and their feet close together against the crosspiece. The performer extended the legs to about shoulder width apart, lifted the weight until the legs were fully extended, and then lowered the weights till they touched the weight beneath them. The individuals were given two minutes of respite after each

successful lift. After each successful lift, the weight was increased by one or two kg. The same procedure was repeated until the participants were no longer capable of completing a successful trial.

Scoring: Total weight lifted was measured in kilograms.

Running-based Anaerobic Sprint Test

Purpose: To assess the subject's anaerobic power.

Equipments: 400 metres track with 35m specific marking in the straight, 2 cones to mark 35m section and stopwatches.

Procedure: Prior to the test, the participants were weighed. They performed 10 minute warm-up and 5-minute cool-down before and after testing. Then they does six 35-meter sprints at top speed, pausing for 10 seconds between each sprint for turnaround. The time taken for each 35-meter sprint was recorded to the nearest 100^{th} of a second.

Scoring: Power output for all sprints was found by the formula:

Power = Force× Velocity or Power = Weight × $Distance^2 \div Time^3$

Anaerobic power=sum of power output of all sprints÷6

Bent Knee Sit-Ups

Purpose: To appraise muscular strength of the abdominal muscles.

Equipments used: Mat and stopwatch were used.

Testing procedure: The subject assumed supine lying position on the mat, knees bent to an angle less than 90 degrees and feet on the mat and heels were between 10 and 12 inches from the buttocks. The hands were clasped behind

the neck and the elbows were placed flat on the mat. A partner held down the feet. On the signal ready ‘start’, the subject brought his head and elbows forward in a curl-up motion by contracting the abdominal muscles. The left elbow touched the right knee and vice versa alternatively. In return to starting position, the elbows touched the mat. These actions constitute one sit-up and it was repeated as many times as possible. After the finishing of one minute, they stopped doing the sit ups.

sit-up was not counted if they did not kept the feet flat in the mat, if they did not kept the fingers clasped behind the neck region, if they failed to contact the elbows with the mat, took rest in between sit-ups.

Scoring: Total sit-ups did in one minute was noted.

Jump and Reach Test

Purpose: To quantify the explosive power while jump vertically up.

Equipments: jump board & chalk pieces.

Description of jump board: The jump board was marked with horizontal lines, one centimeter apart was attached firmly to the wall with the lines parallel to the floor. The score was marked on both sides of the horizontal lines. The jump board was fixed in such a way that the lower edge was just below the reaching height of shortest subject. High reliability has been reported for this test and the investigator found the reliability of 0.92. Therefore, vertical jump test was used in this study.

Testing procedure: The participants, holding a one-inch chalk piece in their hand, stood with his dominant hand facing the jump board. The patient extended his arm vertically and put a mark in the board while keeping his heels on the floor. The height at which he reached was recorded. The patient adopted a highly effective stance, with his feet spread 5 to 10 inches apart and his knees bent to about 115 degrees. The arms were swung downward and backward, and the favoured arm was hoisted vertically by the side of the hand as high as possible. The arm was completely extended at the apex of the jump, and a mark was drawn on the board. This was the height of the jump that was measured. It was not permitted to take a running approach, to take a preliminary hop shortly before the jump, or to stretch the chalk beyond the fingertips level to designate the jumping height. When the protocol was not followed correctly, the test was repeated. The test was repeated three times for each person, with ample rest in between.

Scoring: The difference between reaching and jumping height in centimeter is the individual score. The best of three trials is the final score.

Footeval - Football-Specific Beep Test

The Footeval Test is an incremental and intermittent football (soccer) specific test designed by Manouvrier et al. (2016). The test is based on the 20m shuttle test, though it incorporates dribbling of a soccer ball and 30 second rest periods after every minute.

Purpose: To measure aerobic fitness and skill in soccer players.

Equipment required: 30m x 10m grassed field area, measuring tape, marker cones, soccer balls, soccer goal, portable barrier for reflecting the kicked ball, audio track and audio player.

Course setup: Mark out the testing area as illustrated. There is a shooting area (2m x 0.5m), which is 10 meters from a goal. From this point in the other direction four cones 2.5m apart was placed. Barriers are placed to either side after that, leading to the turning point 19 meters from the start.

Levels: The level step was designed as a warm-up and lasts two minutes. All following levels last for one minute and are followed by a recovery phase of thirty seconds. The first level begins at 6.5km/h and the speed required is increased by 0.5 km/h each level.

Procedure: The participant begun at the goal end, dribbling the ball around the cones. After the last cone, the player plays the ball against a barrier to the side, traps the ball after the rebound, and continues dribbling the ball to the end line. The player stops the ball at the line and waits for the audio cue to start back the other way. This time the player dribbles the ball straight back to the shooting area and kicked towards the goal. The test continued until they are unable to keep up with the audio track. Also, the test was ended if the player makes more than two technical errors within a level (e.g. bad passes, bad shots, or bad ball control).

Scoring: The total number of shuttles was recorded (Manouvrier et al., 2016).

MC Donald Soccer Test

Purpose: To measure general soccer ability, though mainly trapping and passing skills, and is appropriate for most levels.

Equipment Required: A wall, 30 feet wide and 11.5 feet high, 3 soccer balls and stopwatch.

Procedure: A soccer ball is placed on a line, marked 9 feet from the wall. Another two soccer balls are left 9 feet behind the line in the center of the test area. On the signal, "Go" the player kicks the ball against the wall as many times as possible in 30 seconds. In the event of a wild kick, the player may either retrieve the original ball or use one of the two spare balls. (it is OK to use the hands to retrieve a ball). All kicks must performed from the ground behind the restraining line. The test is repeated four times.

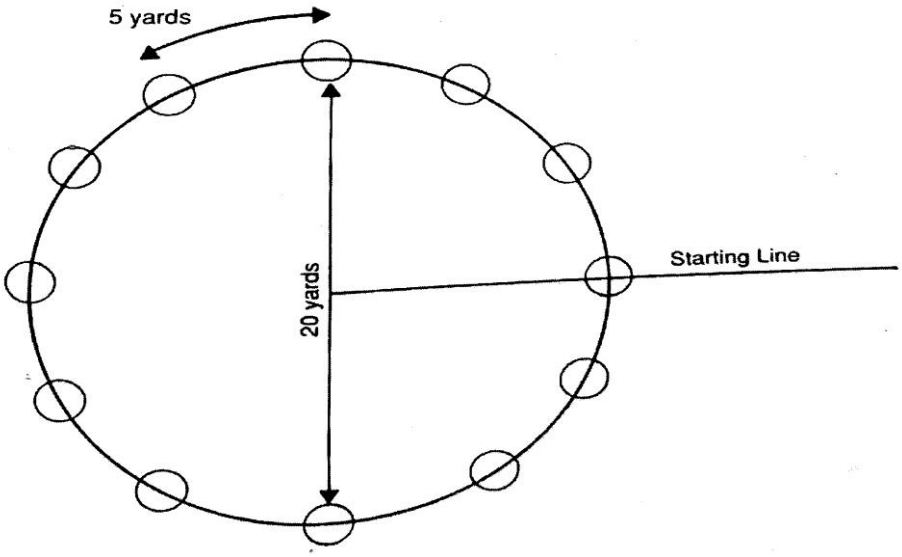
Scoring: The number of kicks in each 30 second period is recorded, with the highest total being the score.

Dribbling Skill Test

Purpose: The reason for conducting this test was to determine the speed of ball dribbling.

Field Marking: A round course 20 yard in measurement was drawn. The beginning line was a 3-foot line attracted opposite to the outside of the circle. Plastic cones 18 inches high were put at 5-yard interims around the circle.

Filed



Marking for the Soccer Dribbling Test

Direction: The ball was set on the beginning line. On the sign, "Prepared Go!" the subject spilled the ball around the round course by weaving among the plastic cones until returning to the beginning line. The spill was performed at all time conceivable. Three trails were given. The main trail was performed in a clock shrewd heading, the second a counterclockwise way, and the third toward the subject's decision.

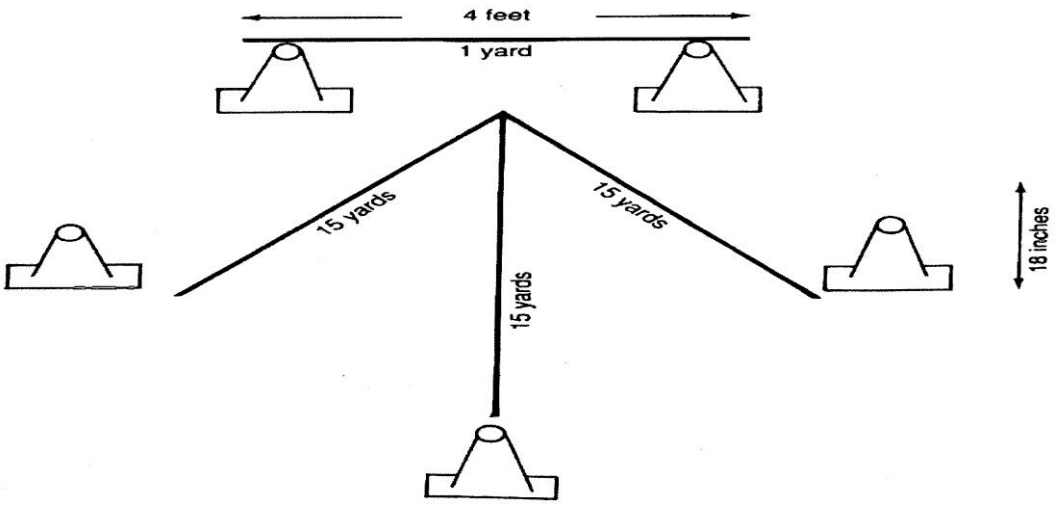
Scoring: The combined best two of the three trails is the test score (Barrow, McGee & Tritschler, 1989).

Passing Skill Test

Purpose: To measure the ability of passing the ball accurately.

Filed Marking: A small goal marked 1 yard in width and 18 inches in height was constructed by utilizing two plastic cones as goal posts, and a 4-foot rope as

the crossbar. Three plastic cones located 15 yards from the goal line were placed at angles of 90 degrees and 45 degrees.



Filed Marking for Soccer Passing Test

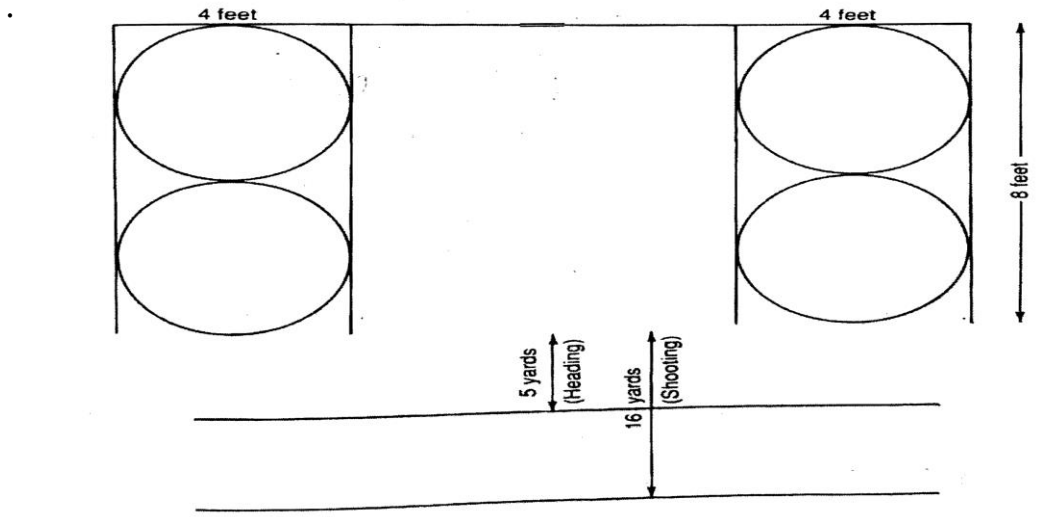
Directions: Students pass a stationary ball with their preferred foot into the small goal from the three angles marked by the cones. Four trails were taken from each angles for a total of 12 trails. Two practice trails from each angle were allowed.

Scoring: A score of one point was given for each successful pass. Balls that rebound from the goal post (plastic cones) were considered successful trails. The score was the total of the 12 trails (Barrow, McGee & Tritschler, 1989).

Shooting Skill Test

Purpose: The purpose of the test was to assess the player's shooting ability.

Filed Marking: The soccer goal was divided into scoring areas by two ropes suspended for the crossbar 4 feet from each goal post. In addition, the scoring areas were divided into 2 circular targets by 2 circular hoops in a diameter of 4 feet. From the designated target area and parallel to it a line was drawn 16 yards.



Filed Marking and Target for the Shooting Test

Direction: The student shoots a stationary ball with the preferred foot from the 16-yard line. The subjects allowed placing the ball at any point along the line. Four practice trails were given, and then four consecutive balls were attempted at each of the four target areas. There were a total of 16 trails.

Scoring: When aiming toward the upper right target, the subject receives a score of 10 points each time the ball was shot through the upper target; a score of 4 points was scored if the ball was shot through the lower right target when aiming at the upper right target. The scoring procedure was identical when the subject was aiming at the lower target, 10 points for the lower and 4 for the upper. The targets on the left side were scored the same way. Balls that rebound from the circular targets were considered a successful trails. No points were given for balls that roll or bounce through the target area (Barrow, McGee & Tritschler, 1989).

COLLECTION OF THE DATA

The data on selected fitness elements and striking variables were gathered from the four training and one control groups before and after the 12 weeks of training. All testing sessions were started with 10-minute standardized warm-up. In the same order and with the same recovery between every trial, all assessments were conducted.

EXPERIMENTAL DESIGN AND STATISTICAL TECHNIQUE

The experimental design used was pre and post test random group design involving 75 participants, who were divided at random into 5 equal groups of 15 participants each. All these participants were chosen from the equivalent population. Prior to the beginning of the treatment, no attempt was made to equate the chosen groups.

The collected all 5 groups (4 experimental and 1 control) data on all chosen dependent variables (fitness elements & striking variables) was analyzed by paired 't' test statistics to discover the differences if any between the 2 tests (pre & post). Additionally, percentage of improvement in fitness elements and striking variables due to experimental treatment was also calculated.

So as to nullify the initial differences in mean (MD)the data collected from the 5 groups prior to and post training periods on chosen dependent variables (fitness elements & striking variables) were analyzed to discover the major difference if any, by Analysis of Covariance(ANCOVA) statistics. The initial (pre) means of the chosen dependent variables (fitness elements& striking

variables) was used as covariate. Since five groups were involved, whenever the derived post test (adjusted) means ‘F’ ratio value was found to be significant, the post hoc test (Scheffe’s) was applied to decide the paired mean differences (MD),if any. The level of confidence for significance was set at 0.05 level.

Chapter IV

ANALYSIS OF THE DATA AND RESULTS OF THE STUDY

To analyze the impact of unilateral and bilateral resistance and plyometric training on chosen fitness elements and striking variables 75soccer players of age from 18 to 21 years were chosen from Mohammed Sathak AJ Engineering College, Siruseri, Chennai and Hindustan College of Arts and Science, Padur, Chennai. Participants were randomly assigned to five different training groups (15 in each group). Group-I performed Unilateral Resistance Training [URT], Group-II performed Unilateral polymeric training [UPT], group-III performed Bilateral Resistance Training [BRT], group-IV performed Bilateral plyometric Training [BPT] and group-V was control[CG].The 4experimental groups participants were experimental treatment during morning session, only 3days in a week for 12weeks, duration.

This study was delimited to the Fitness Elements and tests such as Muscular Strength [I RM Test], Anaerobic Power [RAST], Abdominal Strength Endurance [Sit ups], Explosive Power - Vertical [Sergeant Jump]. This study was also delimited to the Striking Variables and Tests such as Kicking [Mor MC Donald Soccer test], Dribbling [Mor-Christian dribbling Test], Passing [Mor-Christian Passing Test] and Shooting abilities, [Mor-Christian Shooting Test].

The collected 2 tests (pre & post) data on all chosen dependent variables (fitness elements & striking variables) from the 5 groups (4 experimental and 1control) were analyzed by paired ‘t’ test and Analysis of Covariance

(ANCOVA) statistics. Since five groups were involved, whenever the derived post test (adjusted) means 'F' ratio value was found to be significant, the post hoc test (Scheffe's) was applied. The level of confidence for significance was set at 0.05 level. Additionally, percentage of improvement in fitness elements and striking variables due to experimental treatment was also calculated.

Analysis of the Data

The collected five (four experimental & one control) groups data on chosen dependent variables (fitness elements & striking variables) were analyzed by paired 't' test and analysis of covariance (ANCOVA) statistics and the derived results are given in 4.1-4.27.

Analysis of Muscular Strength (MS)

The assessed pre and post test muscular strength (MS) scores of URT, UPT, BT & Control group's are analyzed as in table 4.1-4.3.

Table – 4.1
Paird 't' Test and % of Changes on Soccer Player's Muscular Strength (MS) of URT, UPT, BRT, BPT&CG

Groups Name	Testing Periods	Subjects	Mean Values	SD Values	DM Value	't' – test Value	Percentage
Unilateral Resistance	Pre	15	66.73	3.55	17.40	9.40*	26.19
	Post		84.13	6.74			
Unilateral Plyometric	Pre	15	67.13	2.97	9.98	12.71*	14.89
	Post		77.11	3.54			
Bilateral Resistance	Pre	15	67.53	3.27	12.20	12.07	18.07
	Post		79.73	4.10			
Bilateral Plyometric	Pre	15	67.73	2.65	6.60	13.66*	9.74
	Post		74.33	2.66			
Control	Pre	15	66.33	3.08	1.07	2.62	1.60
	Post		67.40	2.74			

df 14 =2.15 (table value)
*(*significant)*

The assessed pre and post test muscular strength values of four training (URT, UPT, BRT & BPT) groups differ noticeably since the 't' values of URT (9.40), UPT (12.71), BRT (12.07) as well as bilateral plyometric training (BPT=13.66) groups were greater than the table value (df14=2.15). Following 12 weeks of URT, UPT, BRT and BPT treatment, soccer player's muscular strength performance (URT=26.19%, UPT=14.89%, BRT=18.07 and BPT=9.74%), enhanced greatly.

The chosen soccer player's muscular strength (MS) performance of URT, UPT and BT groups were analyzed through ANCOVA statistics, as in table–4.2.

Table – 4.2
ANCOVA Statistics Output on Soccer Player's Muscular Strength (MS) of URT, UPT, BRT, BPT & Control groups

Mean	URTG	UPTG	BRT	BPT	CG	SoV	SS	df	MS	'F' ratio
Adjusted	84.34	77.11	79.48	73.96	67.84	B	2278.61	4	569.65	38.34*
						W	1025.09	69	14.86	

*(Table value for df 4 &69=2.50)*Significant(.05 level)*

The ANCOVA statistics result established that the adjusted final means (URT=84.34, UPT= 77.11, BRT= 79.48, BPT =73.96 & CG=67.84) on soccer player's muscular strength of all (URT, UPT, BRT, BPT & Control**)** chosen groups differs from one another, because the derived adjusted final mean's 'F' value (38.34) is superior to requisite value (df 4 & 69 =2.50).

As the URT, UPT, BRT, BPT & Control group's adjusted final means 'F' value (F= 46.34) is significant, Scheffe's Test was calculated as in table-4.3.

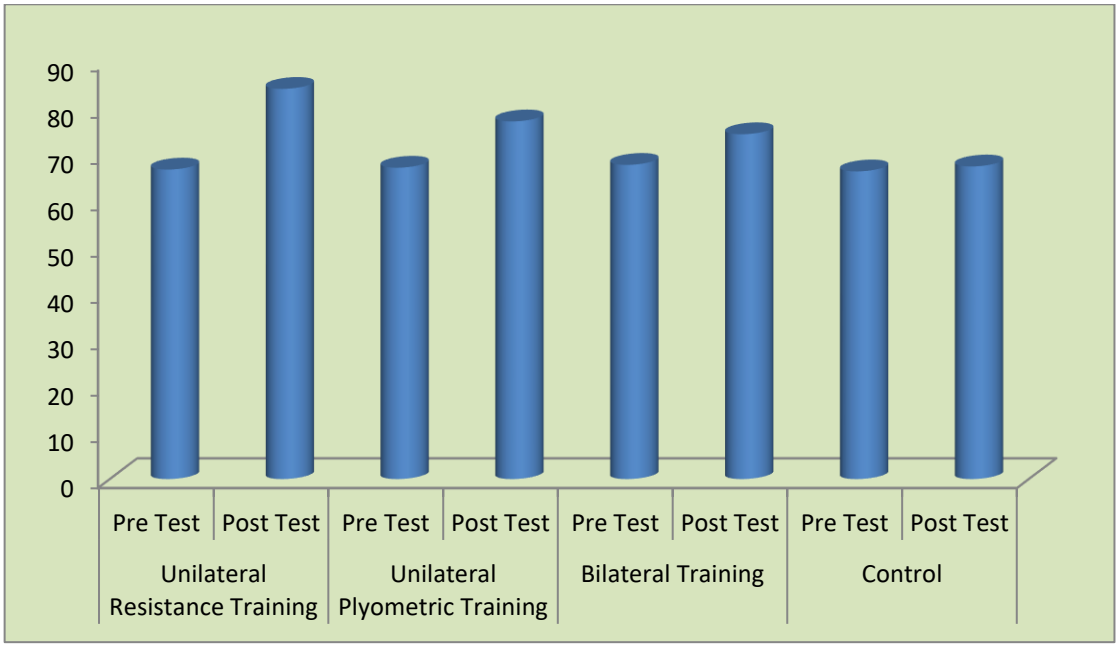
Table – 4.3
Scheffe's Test Outcome on Soccer Player's Muscular Strength (MS) of URT, UPT, BRT, BPT & Control Groups

Variable	Unilateral Resistance Training	Unilateral Plyometric Training	Bilateral Resistance Training	Bilateral plyometric Training	Control	MD	CI
Muscular Strength	84.34	77.11				7.23*	4.45
	84.34		79.48			4.86*	4.45
	84.34			73.96		10.38*	4.45
	84.34				67.84	16.50*	4.45
		77.11	79.48			2.37	4.45
		77.11		73.96		3.15	4.45
		77.11			67.84	9.27*	4.45
			79.48	73.96		5.52*	4.45
			79.48		67.84	11.64*	4.45
				73.96	67.84	6.12*	4.45

**Significant (.05)*

It (Scheffe's Test) proved that due to URT (16.50), UPT (9.27), BRT (11.64) as well as bilateral plyometric training (6.12) the soccer player's muscular strength was greatly improved. Though, URT was much better than UPT (MD=7.23), BRT (MD=4.86), and bilateral plyometric training (MD=10.38) and also bilateral resistance training was greater than bilateral plyometric training (MD=5.52) since these mean differences (16.50, 9.27, 11.64, 6.12, 7.23, 4.86, 10.38 & 5.52) are higher than CI value (4.45). Whereas insignificant differences were found between UPT and BRT (MD=2.37) and also between UPT and BPT (MD=3.15) groups (CI>MD). Chosen URT, UPT, BRT, BPT & Control group's muscular strength scores are graphically displayed in diagram-4a.

Figure – 4a
Figure Showing Soccer Player's Muscular Strength (MS) of URT, UPT, BRT, BPT & Control Groups



Analysis of Anaerobic Power (AP)

The assessed pre and post test anaerobic power (AP) scores of URT, UPT, BRT, BPT & Control group's are analyzed as in table 4.4-4.6

Table – 4.4
Paird't' Test and % of Changes on Soccer Player's Anaerobic Power (AP) of URT, UPT, BRT, BPT&CG

Groups Name	Testing Periods	Subjects	Mean Values	SD Values	DM Value	't' – test Value	Percentage
Unilateral Resistance	Pre	15	227.47	9.49	16.06	5.26*	7.06
	Post		243.53	6.07			
Unilateral Plyometric	Pre	15	229.27	4.28	27.80	21.05*	12.12
	Post		257.07	4.10			
Bilateral resistance	Pre	15	224.80	3.28	12.73	8.60	5.66
	Post		237.53	6.05			
Bilateral plyometric	Pre	15	229.00	4.84	20.46	9.96*	8.55
	Post		245.47	4.25			
Control	Pre	15	226.60	3.58	0.06	0.05	1.77
	Post		226.67	4.71			

*df 14 =2.15 (table value)(*significant)*

The assessed pre and post test anaerobic power (AP) values of three training (URT, UPT & BT) groups differ noticeably since the 't' values of URT (5.26), UPT (21.05), BRT (8.60) as well as bilateral plyometric training (BT=9.96) groups were greater than the table value (df14=2.15). Following 12 weeks of URT, UPT, BRT and BPT treatment, soccer player's anaerobic power performance (URT=7.06%, UPT=12.12%, BRT=5.66 and BPT=8.55%), enhanced greatly.

The chosen soccer player's anaerobic power (AP) performance of URT, UPT, BRT, BPT and control groups were analyzed through ANCOVA statistics, and put on view in table–4.5.

Table – 4.5
ANCOVA Statistics Output on Soccer Player's Anaerobic Power (AP) of URT, UPT, BRT, BPT & Control groups

	URT	**UPT**	**BRT**	**BPT**	**CG**	**SoV**	**SS**	**df**	**MS**	**'F' ratio**
Adjusted Mean	243.5	256.7	238.0	249.2	226.8	B	7323.58	4	1830.9	42.45*
						W	2975.78	69	43.13	

*(Table value for df 4 &69 is 2.50)*Significant (.05 level)*

The ANCOVA statistics result established that the adjusted final means (URT=243.50, UPT=256.70, BRT=238.00 BPT=249.20 & CG=226.80) on soccer player's anaerobic power of all (URT, UPT, BRT, BPT & Control**)** chosen groups differs from one another, because the derived adjusted final mean's 'F' value (42.45) is superior to requisite value (*df 4 & 69* =2.50).

As the URT, UPT, BRT, BPT & Control group's adjusted final means 'F' value (F= 93.35) is significant, further statistics Scheffe's Test was calculated as in table-4.6.

Table – 4.6
Scheffe's Test Outcome on Soccer Player's Anaerobic Power (AP) of URT, UPT, BRT, BPT & Control Groups

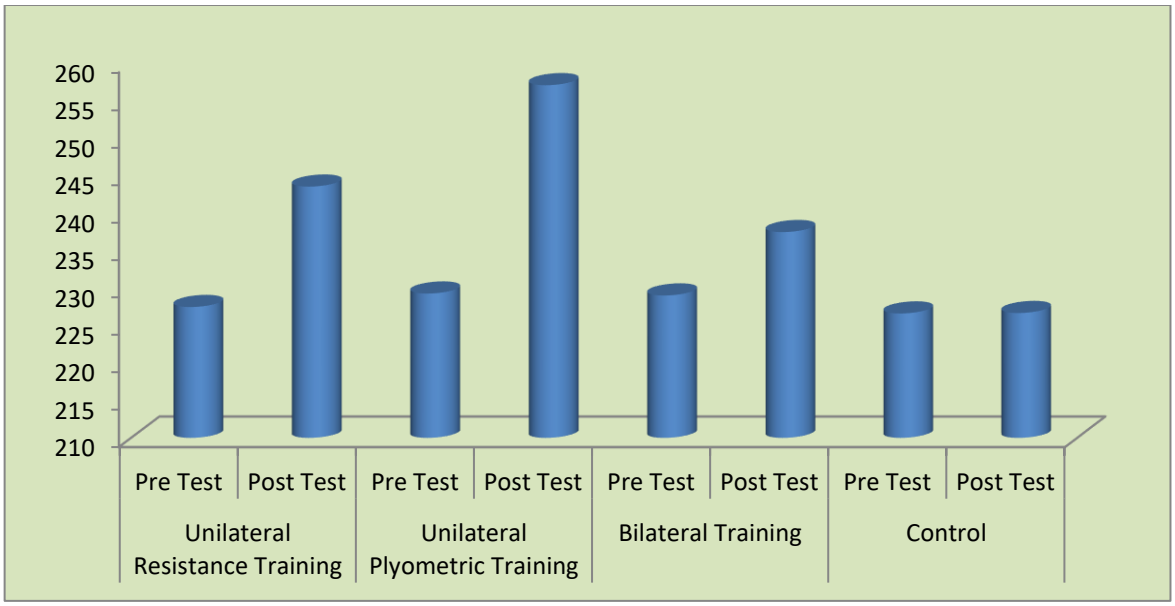
Variable	Unilateral Resistance Training	Unilateral Plyometric Training	Bilateral Resistance Training	Bilateral Plyometric Training	Control	MD	CI
Anaerobic Power (AP)	243.50	256.70				13.18*	7.54
	243.50		238.00			5.48*	7.54
	243.50			249.20		5.63*	7.54
	243.50				226.80	16.70*	7.54
		256.70	238.00			18.66*	7.54
		256.70		249.20		7.55*	7.54
		256.70			226.80	29.88*	7.54
			238.00	249.20		11.11*	7.54
			238.00		226.80	11.22*	7.54
				249.20	226.80	22.33*	7.54

**Significant (.05)*

It (Scheffe's Test) proved that due to URT (16.70), UPT (29.88), BRT (11.22) as well as bilateral plyometric training (22.33) the soccer player's anaerobic power was greatly improved. Though, UPT was much better than BPT (MD=7.55), URT (MD=13.18) and bilateral resistance training (MD=18.66). Further, URT was much better than bilateral resistance training (MD=5.48) and bilateral plyometric training was better than unilateral resistance (MD=5.63) and bilateral resistance training(MD=11.11). The mean differences (16.70, 29.88, 11.22, 22.33, 7.55, 13.18, 18.66, 5.48, 5.63 & 11.11) are higher than CI value (7.54).

Chosen URT, UPT, BRT, BPT & Control group's anaerobic power scores are graphically displayed in diagram-4b.

Figure – 4b
Figure Showing Soccer Player's Anaerobic Power (AP) of URT, UPT, BRT, BPT & Control Groups



Analysis of Strength Endurance (SE)

The assessed pre and post test strength endurance (SE) scores of URT, UPT, BRT, BPT & Control group's are analyzed as in table 4.7-4.9.

Table – 4.7
Paird't' Test and % of Changes on Soccer Player's Strength Endurance (SE) of URT, UPT, BRT, BPT&CG

Groups Name	Testing Periods	Subjects	Mean Values	SD Values	DM Value	't' – test Value	Percentage
Unilateral Resistance	Pre	15	27.33	1.35	7.00	41.41*	25.60
	Post		34.33	1.68			
Unilateral Plyometric	Pre	15	27.53	1.36	3.07	46.00*	11.15
	Post		30.60	1.45			
Bilateral Resistance	Pre	15	27.13	1.35	5.00	29.58*	18.43
	Post		32.13	1.45			
Bilateral plyometric	Pre	15	25.93	1.91	4.80	24.00*	18.51
	Post		30.73	2.37			
Control	Pre	15	27.27	1.43	0.33	0.60	1.22
	Post		27.60	1.80			

df 14 =2.15 (table value)
*(*significant)*

The assessed pre and post test strength endurance (SE) values of four training (URT, UPT, BRT & BPT) groups differ noticeably since the 't' values of URT (41.41), UPT (46.00), BRT (29.58) as well as bilateral plyometric training (BPT=24.00) groups were greater than the table value (df14=2.15). Following 12 weeks of URT, UPT and BT treatment, soccer player's strength endurance performance (URT=25.60%, UPT=11.15%, BRT=18.43 and BPT=18.51%), enhanced greatly.

The chosen soccer player's strength endurance (SE) performance of URT, UPT, BRT, BPT and CG groups were analyzed through ANCOVA statistics, and put on view in table–4.8.

Table – 4.8
ANCOVA Statistics Output on Soccer Player's Strength Endurance (SE) of URT, UPT, BRT, BPT & Control groups

	URT	**UPT**	**BRT**	**BPT**	**CG**	**SoV**	**SS**	**df**	**MS**	**'F' ratio**
Adjusted Mean	34.05	30.12	32.04	31.80	27.38	B	371.39	4	92.85	74.06*
						W	86.50	69	1.25	

*(Table value for df 4 &69 is 2.50)*Significant (.05 level)*

The ANCOVA statistics result established that the adjusted final means (URT=32.13, UPT=34.33, BT=30.60 & CG=27.60) on soccer player's strength endurance of all (URT, UPT, BRT, BPT & Control**)** chosen groups differs from one another, because the derived adjusted final mean's 'F' value (87.34) is superior to requisite value (df 4 & 69 =2.50).

As the URT, UPT, BRT, BPT & Control group's adjusted final means 'F' value (F= 87.34) is significant, further statistics Scheffe's Test was calculated as in table-4.9.

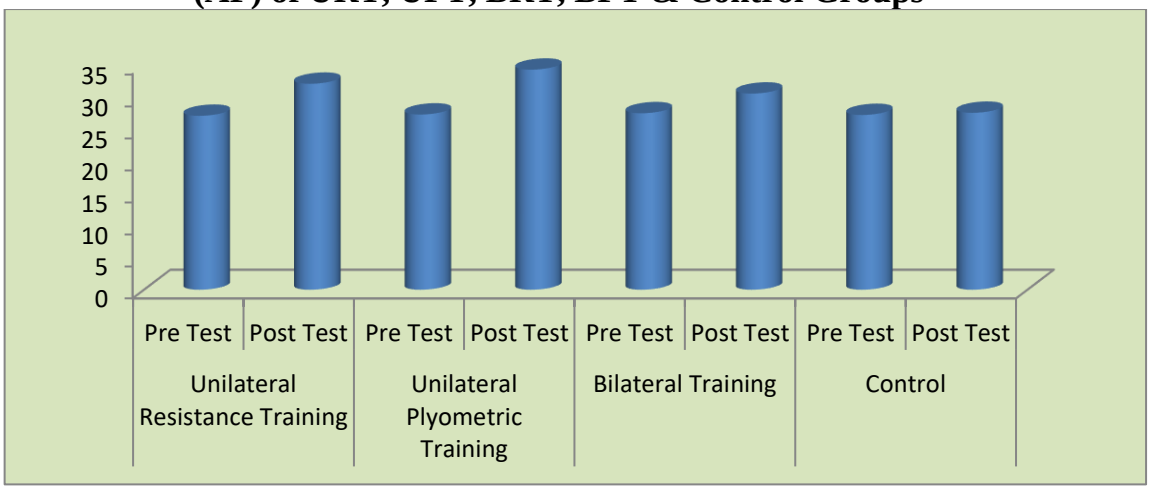
Table – 4.9
Scheffe's Test Outcome on Soccer Player's Strength Endurance (SE) of URT, UPT, BRT, BPT & Control Groups

Variable	Unilateral Resistance Training	Unilateral Plyometric Training	Bilateral resistance Training	Bilateral plyometric Training	Control	MD	CI
Strength Endurance (SE)	34.05	30.12				3.93*	1.29
	34.05		32.04			2.01*	1.29
	34.05			31.80		2.25*	1.29
	34.05				27.38	6.67*	1.29
		30.12	32.04			1.92*	1.29
		30.12		31.80		1.68*	1.29
		30.12			27.38	2.74*	1.29
			32.04	31.80		0.24	1.29
			32.04		27.38	4.66*	1.29
				31.80	27.38	4.42*	1.29

**Significant (.05)*

It (Scheffe's Test) proved that due to URT (6.67), UPT (2.74), BRT (4.66) as well as bilateral plyometric training (4.42) the soccer player's strength endurance was greatly improved. Though, URT was much better than UPT (MD=3.99), bilateral resistance training (MD=2.01) and bilateral plyometric training (MD=2.25). Further, bilateral resistance (BRT=1.92) and plyometric training (BPT=1.68) groups are better to UPT training whereas insignificant difference was found between bilateral resistance (BRT) and plyometric training (BPT) (MD=0.24). The mean differences (6.67, 2.74, 4.66, 4.42, 3.93, 2.01, 2.25, 1.92 & 1.68) are higher than CI value (1.29). Chosen URT, UPT, BT & Control group's strength endurance scores are graphically displayed in diagram-4c.

Figure – 4c
Figure Showing Soccer Player's Strength Endurance (AP) of URT, UPT, BRT, BPT & Control Groups



Analysis of Vertical Explosive Power (VEP)

The assessed pre and post test explosive power (EP) scores of URT, UPT, BRT, BPT & Control group's are analyzed as in table 4.10-4.12.

Table – 4.10
Paird't' Test and % of Changes on Soccer Player's Vertical Explosive Power (VEP) of URT, UPT, BRT, BPT&CG

Groups Name	Testing Periods	Subjects	Mean Values	SD Values	DM Value	't' – test Value	Percentage
Unilateral Resistance	Pre	15	31.40	1.35	2.27	6.86*	7.23
	Post		33.67	1.29			
Unilateral Plyometric	Pre	15	31.33	1.23	5.20	29.79*	16.60
	Post		36.53	1.41			
Bilateral Resistance	Pre	15	31.20	1.37	1.60	7.48*	6.41
	Post		32.80	1.37			
Bilateral Plyometric	Pre	15	31.80	1.90	3.47	12.67*	5.13
	Post		35.27	2.05			
Control	Pre	15	30.80	1.38	0.27	0.41	0.86
	Post		30.53	1.40			

df 14 =2.15 (table value)
*(*significant)*

The assessed pre and post test explosive power (EP) values of four training (URT, UPT, BRT & BPT) groups differ noticeably since the 't' values of URT (6.86), UPT (29.79), BRT(7.48) as well as bilateral training (BPT=12.67) groups were greater than the table value (df14=2.15). Following 12 weeks of URT, UPT, BRT and BPT treatment, soccer player's explosive power performance (URT=7.23%, UPT=16.60%, BRT=6.41 and BT=5.13%), enhanced greatly.

The chosen soccer player's explosive power (EP) performance of URT, UPT, BRT, BPT and CG groups were analyzed through ANCOVA statistics, and put on view in table–4.11.

Table – 4.11
ANCOVA Statistics Output on Soccer Player's Vertical Explosive Power (VEP) of URT, UPT, BRT, BPT & Control groups

	URT	**UPT**	**BRT**	**BPT**	**CG**	**SoV**	**SS**	**df**	**MS**	**'F' ratio**
Adjusted Mean	33.61	36.52	32.86	34.98	30.83	B	271.03	4	67.76	40.84*
						W	114.49	69	1.66	

*(Table value for df 4 &69 is 2.50)*Significant (.05 level)*

The ANCOVA statistics result established that the adjusted final means (URT=34.34, UPT= 36.44 BT=33.19 & CG=30.75) on soccer player's explosive power of all (URT, UPT, BT & Control**)** chosen groups differs from one another, because the derived adjusted final mean's 'F' value (74.14) is superior to requisite value (df 4 & 69 =2.50).

As the URT, UPT, BRT, BPT & Control group's adjusted final means 'F' value (F= 74.14) is significant, further Scheffe's Test was calculated as in table-4.12.

Table – 4.12
Scheffe's Test Outcome on Soccer Player's Vertical Explosive Power (VEP) of URT, UPT, BRT, BPT & Control Groups

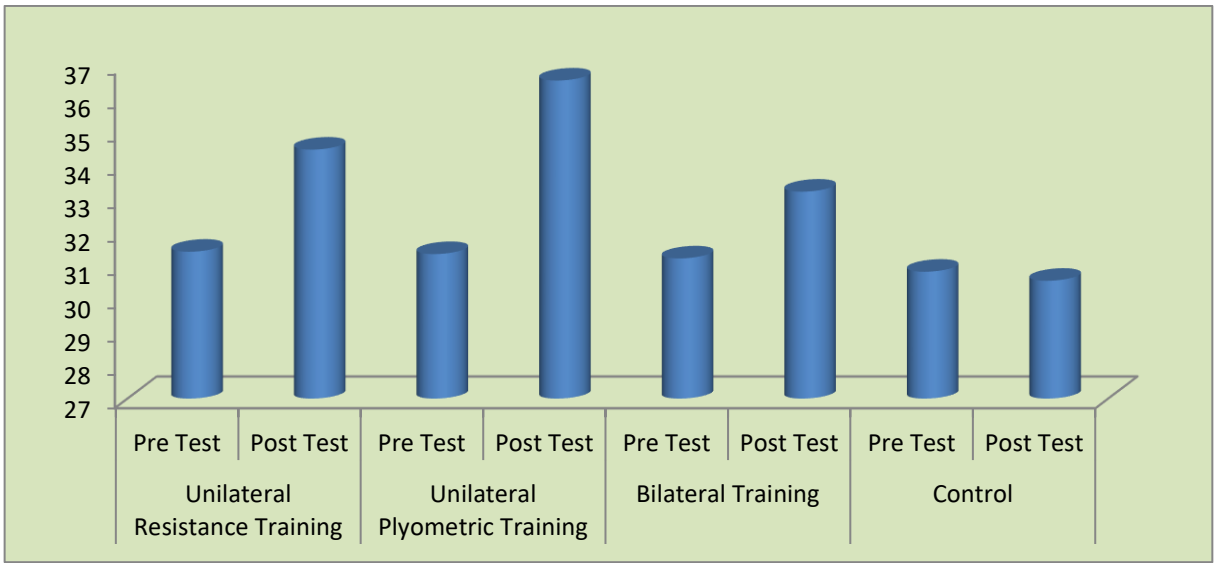
Variable	Unilateral Resistance Training	Unilateral Plyometric Training	Bilateral resistance Training	Bilateral plyomeyric Training	Control	MD	CI
Vertical Explosive Power (VEP)	33.61	36.52				2.91*	1.35
	33.61		32.86			0.75	1.35
	33.61			34.98		1.37*	1.35
	33.61				30.83	2.79*	1.35
		36.52	32.86			3.66*	1.35
		36.52		34.98		1.54*	1.35
		36.52			30.83	5.69*	1.35
			32.86	34.98		2.12*	1.35
			32.86		30.83	2.04*	1.35
				34.98	30.83	4.16*	1.35

**Significant (.05)*

It (Scheffe's Test) proved that due to URT (2.79), UPT (5.69), BRT (2.04) as well as bilateral plyometric training (4.16) the soccer player's explosive power (vertical) was greatly improved. Though, UPT was much better than URT (MD=2.91), bilateral resistance training (MD=3.66) and bilateral plyometric training (MD=1.54). Further, bilateral plyometric training (BPT) is better to BRT (MD=2.12) and URT (MD=1.35) training. The mean differences (2.79, 5.69, 2.04, 4.16, 2.91, 3.66, 1.54, 2.12 & 1.35) are higher than CI value (1.35). Whereas insignificant difference was found between bilateral resistance (BRT) and unilateral resistance training (URT) (MD=0.75).

Chosen URT, UPT, BRT, BPT & Control group's explosive power scores are graphically displayed in diagram-4d.

Figure – 4d
Figure Showing Soccer Player's Explosive Power (AP) of URT, UPT, BRT, BPT & Control Groups



Analysis of Aerobic Fitness (AF)

The assessed pre and post test aerobic fitness (AF) scores of URT, UPT, BRT, BPT & Control group's are analyzed as in table 4.13-4.15.

Table – 4.13
Paird't' Test and % of Changes on Soccer Player's Aerobic Fitness (AF) of URT, UPT, BRT, BPT&CG

Groups Name	Testing Periods	Subjects	Mean Values	SD Values	DM Value	't' – test Value	Percentage
Unilateral Resistance	Pre	15	10.30	0.73	0.71	3.52*	6.52
	Post		11.02	0.44			
Unilateral Plyometric	Pre	15	10.62	1.13	0.61	4.47*	5.48
	Post		11.23	0.28			
Bilateral Resistance	Pre	15	10.95	0.48	0.88	2.83*	8.06
	Post		10.07	0.49			
Bilateral Plyometric	Pre	15	10.37	0.73	0.65	3.30*	5.89
	Post		11.03	0.46			
Control	Pre	15	10.02	0.68	0.11	0.46	1.00
	Post		9.91	0.71			

df 14 =2.15 (table value)
*(*significant)*

The assessed pre and post test aerobic fitness (AF) values of four training (URT, UPT, BRT & BPT) groups differ noticeably since the 't' values of URT (3.52), UPT (4.47), BRT (2.83) as well as bilateral training (BPT=3.30) groups were greater than the table value (df14=2.15). Following 12 weeks of URT, UPT, BRT and BPT, soccer player's aerobic fitness performance (URT=6.52%, UPT=5.48%, BRT=8.06% and BPT=5.89%), enhanced greatly.

The chosen soccer player's aerobic fitness (AF) performance of URT, UPT, BRT, BPT and CG groups were analyzed through ANCOVA statistics, and put on view in table–4.14.

Table – 4.14
ANCOVA Statistics Output on Soccer Player's Aerobic Fitness (AF) of URT, UPT, BRT, BPT & Control groups

	URT	**UPT**	**BRT**	**BPT**	**CG**	**SoV**	**SS**	**df**	**MS**	**'F' ratio**
Adjusted Mean	10.61	10.91	10.09	10.38	9.05	B	7.76	4	1.94	8.04*
						W	16.64	69	0.24	

*(Table value for df 4 &69 is 2.50)*Significant (.05 level)*

The ANCOVA statistics result established that the adjusted final means (URT=10.61, UPT=10.91, BRT= 10.09, BPT=10.38 & CG=9.05) on soccer player's aerobic fitness of all (URT, UPT, BRT, BPT & Control**)** chosen groups differs from one another, because the derived adjusted final mean's 'F' value (8.04) is superior to requisite value (df 4 & 69 =2.50).

As the URT, UPT, BRT, BPT & Control group's adjusted final means 'F' value (F= 8.04) is significant, further statistics Scheffe's Test was calculated as in table-4.15.

Table – 4.15
Scheffe's Test Outcome on Soccer Player's Aerobic Fitness (AF) of URT, UPT, BRT, BPT & Control Groups

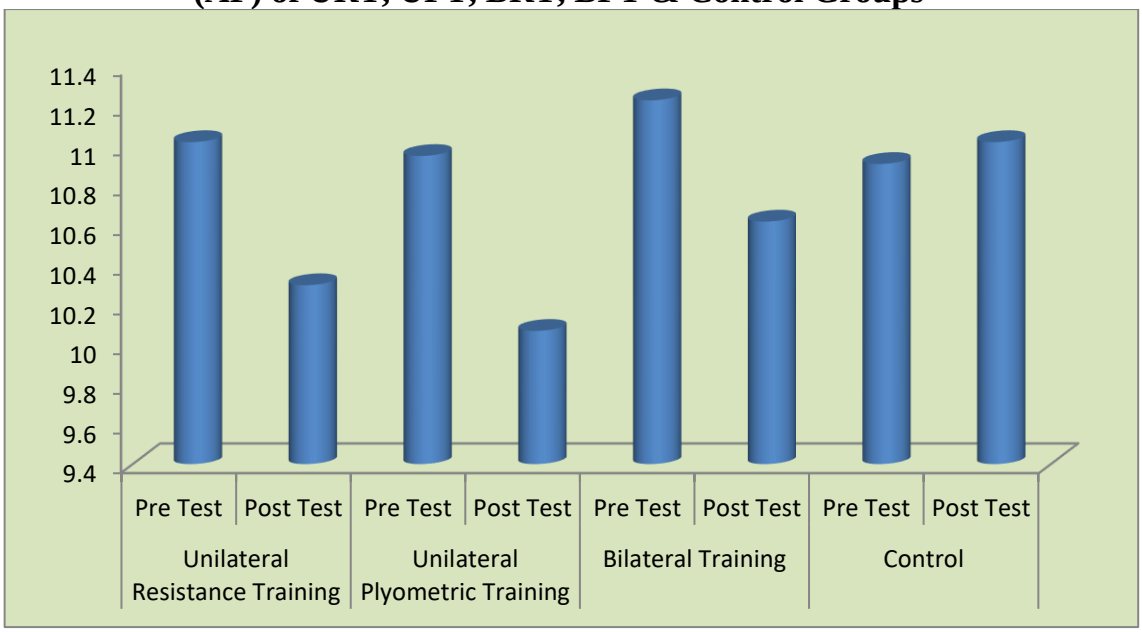
Variable	Unilateral Resistance Training	Unilateral Plyometric Training	Bilateral Resistance Training	Blateral Plyometric Training	Control	MD	CI
Aerobic Fitness (AF)	10.61	10.91				0.31*	0.23
	10.61		10.09			0.52*	0.23
	10.61			10.38		0.23*	0.23
	10.61				9.05	1.56*	0.23
		10.91	10.09			0.82*	0.23
		10.91		10.38		0.53*	0.23
		10.91			9.05	1.86*	0.23
			10.09	10.38		0.29*	0.23
			10.09		9.05	1.04*	0.23
				10.38	9.05	1.33*	0.23

**Significant (.05)*

It (Scheffe's Test) proved that due to URT (1.56), UPT (1.86), BRT (1.04) as well as bilateral plyometric training (1.33) the soccer player's aerobic fitness was significantly improved. Though, UPT was much better than URT (0.31), BRT (MD=0.82) and bilateral plyometric training (MD=0.53). Further, URT was better than BRT (MD=0.52) and bilateral plyometric training (BPT) (MD=0.23) and BPT was better than BRT (MD=0.29). The mean differences (1.56, 1.86, 1.04, 1.33, 0.31, 0.82, 0.53, 0.52 & 0.23) are higher than CI value (0.23).

Chosen URT, UPT, BRT, BPT & Control group's aerobic fitness scores are graphically displayed in diagram-4d.

Figure – 4d
Figure Showing Soccer Player's Aerobic Fitness (AP) of URT, UPT, BRT, BPT & Control Groups



Analysis of Kicking Ability (KA)

The assessed pre and post test kicking (K) scores of URT, UPT, BRT, BPT & Control group's are analyzed as in table 4.16-4.19.

Table – 4.16
Paird't' Test and % of Changes on Soccer Player's Kicking Ability (KA) of URT, UPT, BRT, BPT & CG

Groups Name	Testing Periods	Subjects	Mean Values	SD Values	DM Value	't' – test Value	Percentage
Unilateral Resistance	Pre	15	27.73	1.83	2.93	8.51*	10.57
	Post		30.66	1.34			
Unilateral Plyometric	Pre	15	28.00	1.77	3.66	7.41*	10.94
	Post		31.66	1.95			
Bilateral Resistance	Pre	15	28.07	1.83	0.93	6.09*	3.31
	Post		29.00	2.00			
Bilateral Plyometric	Pre	15	28.20	1.65	1.53	5.60*	6.05
	Post		29.73	1.75			
Control	Pre	15	26.93	1.83	0.06	0.05	0.23
	Post		26.86	4.59			

df 14 =2.15 (table value)
*(*significant)*

The assessed pre and post test kicking (K) values of four training (URT, UPT, BRT, BPT) groups differ noticeably since the 't' values of URT (8.51), UPT (7.41), BRT (6.09) as well as bilateral plyometric training (BPT=5.60) groups were greater than the table value (df14=2.15). Following 12 weeks of URT, UPT and BT treatment, soccer player's kicking performance (URT=10.57%, UPT=10.94%, BRT=3.31% and BPT=6.05%), enhanced greatly.

The chosen soccer player's kicking (K) performance of URT, UPT, BRT, BPT and CG groups were analyzed through ANCOVA statistics, and put on view in table–4.17.

Table – 4.17
ANCOVA Statistics Output on Soccer Player's Kicking Ability (KA) of URT, UPT, BRT, BPT & Control Groups

	URT	**UPT**	**BRT**	**BPT**	**CG**	**SoV**	**SS**	**df**	**MS**	**'F' ratio**
Adjusted Mean	30.64	33.52	28.88	29.52	26.84	B	277.99	4	69.50	12.30 *
						W	389.90	69	5.65	

*(Table value for df 4 &69 is 2.50)*Significant (.05 level)*

The ANCOVA statistics result established that the adjusted final means (URT=30.64, UPT= 33.52, BRT=28.88, BPT=29.52 & CG=26.84) on soccer player's kicking of all (URT, UPT, BRT, BPT & Control**)** chosen groups differs from one another, because the derived adjusted final mean's 'F' value (12.30) is superior to requisite value (df 4 & 69 =2.50).

As the URT, UPT, BRT, BPT & Control group's adjusted final means 'F' value (F= 12.30) is significant, further statistics Scheffe's Test was calculated as in table number-4.18.

Table – 4.18
Scheffe's Test Outcome on Soccer Player's Kicking Ability (KA) of URT, UPT, BRT, BPT & Control Groups

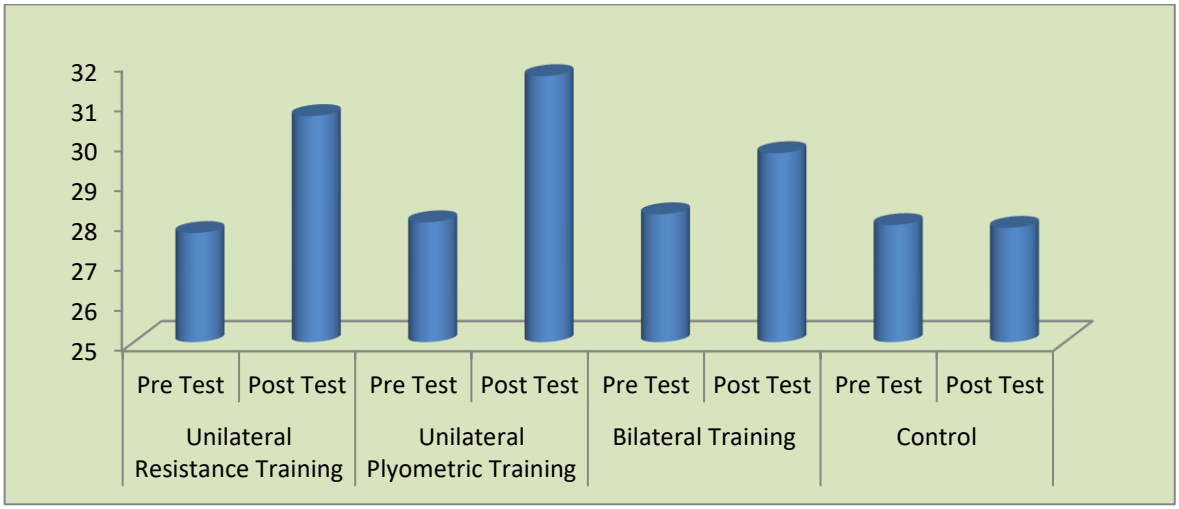
Variable	Unilateral Resistance Training	Unilateral Plyometric Training	Bilateral Resistance	Bilateral Plyometric	Control	MD	CI
Muscular Strength	30.64	33.52				2.88*	2.04
	30.64		28.88			1.76	2.04
	30.64			29.52		1.12	2.04
	30.64				26.84	3.80*	2.04
		33.52	28.88			4.64*	2.04
		33.52		29.52		3.99*	2.04
		33.52			26.84	6.68*	2.04
			28.88	29.52		0.64	2.04
			28.88		26.84	2.04*	2.04
				29.52	26.84	2.68*	2.04

**Significant (.05)*

It (Scheffe's Test) proved that due to URT (3.80), UPT (6.68), BRT (2.04) as well as bilateral plyometric training (2.68) the soccer player's kicking ability was greatly improved. Though, UPT was much better than URT, BRT as well as bilateral plyometric training since the mean differences (2.88, 4.64 & 3.99) are higher than CI value (2.04). The mean differences (3.80, 6.68, 2.04, 2.68, 2.88, 4.64 & 3.99) are higher than CI value (2.04). Whereas insignificant differences were found between URT and BRT groups (CI>1.76), URT and BPT groups (CI>1.12) and also between BRT and BPT groups (CI>0.64).

Chosen URT, UPT, BRT, BPT & Control group's kicking scores are graphically displayed in diagram-4f.

Figure – 4f
Figure Showing Soccer Player's Kicking
(AP) of URT, UPT, BRT, BPT & Control Groups



Analysis of Dribbling Ability (DA)

The assessed pre and post test Dribbling (DA) scores of URT, UPT, BRT, BPT & Control group's are analyzed as in table 4.19-4.21

Table – 4.19
Paird't' Test and % of Changes on Soccer Player's Dribbling Ability (DA) of URT, UPT, BRT, BPT&CG

Groups Name	Testing Periods	Subjects	Mean Values	SD Values	DM Value	't' – test Value	Percentage
Unilateral Resistance	Pre	15	15.46	1.06	1.06	16.00*	12.93
	Post		17.47	1.06			
Unilateral Plyometric	Pre	15	15.40	1.12	4.00	25.12*	25.97
	Post		19.40	1.12			
Bilateral Resistance	Pre	15	15.67	1.05	0.67	5.29*	4.28
	Post		16.33	1.29			
Bilateral Plyometric	Pre	15	15.66	1.04	1.09	8.41*	6.80
	Post		16.73	0.96			
Control	Pre	15	15.80	1.32	0.13	0.27	0.84
	Post		15.66	1.44			

*df 14 =2.15 (table value) (*significant)*

The assessed pre and post test dribbling (DA) values of four training (URT, UPT, BRT & BPT) groups differ noticeably since the 't' values of URT (16.00), UPT (25.12), BRT (5.29) as well as bilateral plyometric training (BPT=8.41) groups were greater than the table value (df14=2.15). Following 12 weeks of URT, UPT, BRT and BPT treatment, soccer player's dribbling performance (URT=12.93%, UPT=25.97%, BRT=4.28% and BT=6.80%), enhanced greatly.

The chosen soccer player's football dribbling performance of URT, UPT, BRT, BPT and CG groups were analyzed through ANCOVA statistics, and put on view in table number–4.20.

Table – 4.20
ANCOVA Statistics Output on Soccer Player's Dribbling Ability (DA) of URT, UPT, BRT, BPT & Control Groups

	URT	**UPT**	**BRT**	**BPT**	**CG**	**SoV**	**SS**	**df**	**MS**	**'F' ratio**
Adjusted Mean	17.47	19.40	16.33	16.73	15.67	B	141.34	4	35.34	50.11*
						W	48.66	69	0.71	

*(Table value for df 4 &69 is 2.50)*Significant (.05 level)*

The ANCOVA statistics result established that the adjusted final means (URT=17.47, UPT=19.40, BRT=16.33, BPT=16.73 & CG=15.67) on soccer player's dribbling of all (URT, UPT, BRT, BPT & Control**)** chosen groups differs from one another, because the derived adjusted final mean's 'F' value (50.11) is superior to requisite value (df 4 & 69 =2.50).

As the URT, UPT, BRT, BPT & Control group's adjusted final means 'F' value (F= 50.11) is significant, further statistics Scheffe's Test was calculated as in table-4.21.

Table – 4.21
Scheffe's Test Outcome on Soccer Player's Dribbling Ability (DA) of URT, UPT, BRT, BPT & Control Groups

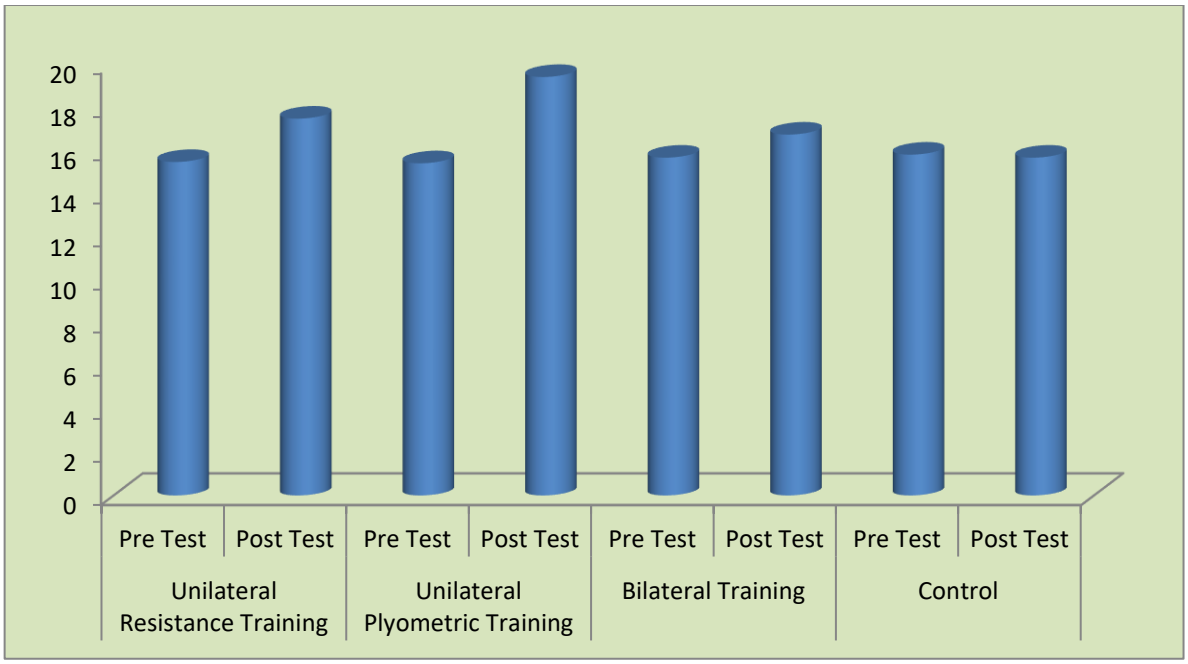
Variable	Unilateral Resistance Training	Unilateral Plyometric Training	Bilateral Resistance Training	Bilateral plyometric Training	Control	MD	CI
Dribbling Ability (DA)	17.47	19.40				1.98*	0.76
	17.47		16.33			1.28*	0.76
	17.47			16.73		0.88	0.76
	17.47				15.67	2.05*	0.76
		19.40	16.33			3.27*	0.76
		19.40		16.73		2.87*	0.76
		19.40			15.67	4.04*	0.76
			16.33	16.73		0.40	0.76
			16.33		15.67	0.77*	0.76
				16.73	15.67	1.17*	0.76

**Significant (.05)*

It (Scheffe's Test) proved that due to URT (2.05), UPT (4.04), BRT=0.77 as well as bilateral plyometric training (1.17) the soccer player's dribbling ability was significantly improved. Though, UPT was much better than URT, BRT as well as bilateral plyometric training since the mean differences (1.98, 3.27 & 2.87) are higher than CI value (0.76). The mean differences (2.05, 4.04, 0.77, 1.17, 1.98, 3.27 & 2.87) are higher than CI value (0.76). And also URT was much better than BRT (MD=1.28) since the mean differences (1.28) is higher than CI value (0.76). Whereas, insignificant differences were found between URT and BPT groups (CI>0.88) and also between BRT and BPT groups (CI>0.40).

Chosen URT, UPT, BRT, BPT & Control group's dribbling scores are graphically displayed in diagram-4f.

Figure – 4f
Figure Showing Soccer Player's Dribbling (AP) of URT, UPT, BRT, BPT & Control Groups



Analysis of Passing Ability (PA)

The assessed pre and post test Passing (PA) scores of URT, UPT, BRT, BPT & Control group's are analyzed as in table 4.22-4.24.

Table – 4.22
Paird't' Test and % of Changes on Soccer Player's Passing Ability (PA) of URT, UPT, BRT, BPT&CG

Groups Name	Testing Periods	Subjects	Mean Values	SD Values	DM Value	't' – test Value	Percentage
Unilateral Resistance	Pre	15	6.53	1.12	3.00	14.21*	25.91
	Post		9.53	1.13			
Unilateral Plyometric	Pre	15	6.40	1.05	4.13	25.49*	34.58
	Post		10.53	1.12			
Bilateral Resistance	Pre	15	6.47	0.99	1.13	4.43*	17.47
	Post		7.60	1.68			
Bilateral Resistance	Pre	15	6.46	0.99	2.00	12.35*	30.92
	Post		8.46	0.99			
Control	Pre	15	6.60	1.05	0.46	0.92	5.05
	Post		6.26	1.03			

df 14 =2.15 (table value)
*(*significant)*

The assessed pre and post test passing (PA) skill values of four training (URT, UPT, BRT, BPT) groups differ noticeably since the 't' values of URT (14.21), UPT (25.49), BRT (4.43) as well as bilateral training (BT=12.35) groups were greater than the table value (df14=2.15). Following 12 weeks of URT, UPT, BRT and BPT treatment, soccer player's Passing performance (URT=25.91%, UPT=34.58%, BRT=17.47% and BPT=30.92%), enhanced greatly.

The chosen soccer player's passing (PA) performance of URT, UPT, BRT, BPT and CG groups were analyzed through ANCOVA statistics, and put on view in table–4.23.

Table – 4.23
ANCOVA Statistics Output on Soccer Player's Passing Ability (PA) of URT, UPT, BRT, BPT & Control Groups

	URT	**UPT**	**BRT**	**BPT**	**CG**	**SoV**	**SS**	**df**	**MS**	**'F' ratio**
Adjusted Mean	9.50	10.62	7.62	8.49	6.17	B	174.59	4	43.65	71.68*
						W	42.02	69	0.61	

*(Table value for df 4 &69 is 2.50)*Significant (.05 level)*

The ANCOVA statistics result established that the adjusted final means (URT=9.50, UPT=10.62, BRT=7.62, BPT=8.49 & CG=6.17) on soccer player's passing of all (URT, UPT, BRT, BPT & Control**)** chosen groups differs from one another, because the derived adjusted final mean's 'F' value (71.68) is superior to requisite value (df 4 & 69 =2.50).

As the URT, UPT, BRT, BPT & Control group's adjusted final means 'F' value (F= 71.68) is significant, further statistics Scheffe's Test was calculated as in table-4.3.

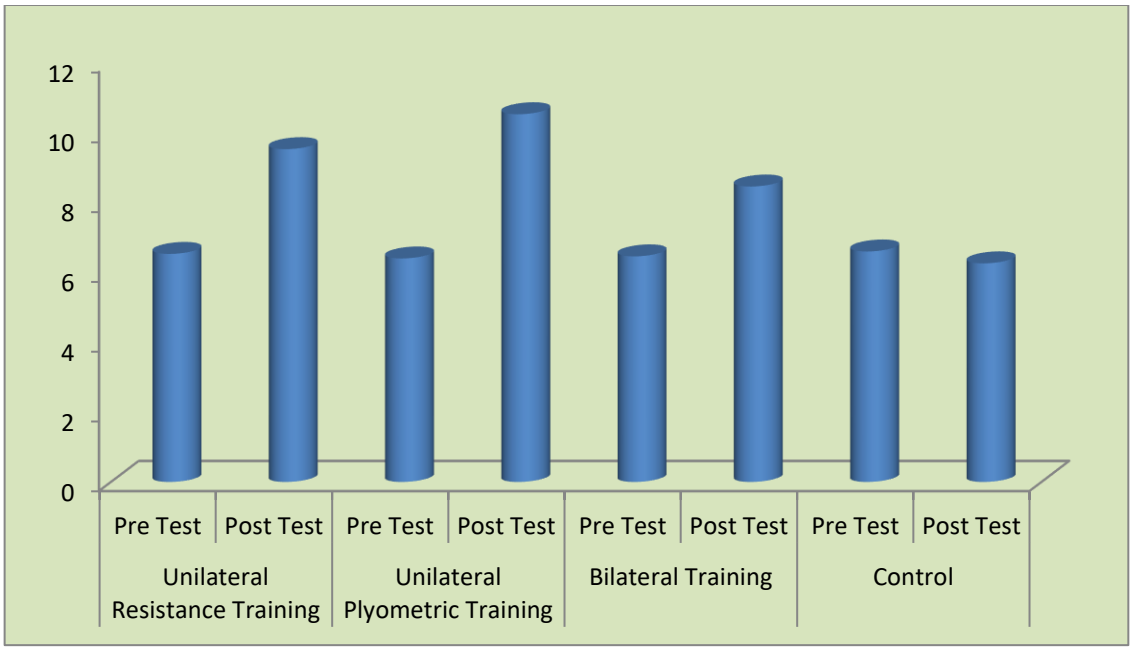
Table – 4.24
Scheffe's Test Outcome on Soccer Player's Passing Ability (PA) of URT, UPT, BRT, BPT & Control Groups

Variable	Unilateral Resistance Training	Unilateral Plyometric Training	Bilateral Resistance Training	Bilateral Plyometric Training	Control	MD	CI
Passing Ability (PA)	9.50	10.62				1.12*	0.90
	9.50		7.62			1.87*	0.90
	9.50			8.49		1.01*	0.90
	9.50				6.17	3.33*	0.90
		10.62	7.62			2.99*	0.90
		10.62		8.49		2.13*	0.90
		10.62			6.17	4.45*	0.90
			7.62	8.49		0.87	0.90
			7.62		6.17	1.45*	0.90
				8.49	6.17	2.32*	0.90

**Significant (.05)*

It (Scheffe's Test) proved that due to URT (3.33), UPT (4.45), BRT (1.45) as well as bilateral plyometric training (2.32) the soccer player's passing ability was very much improved. Though, UPT was much better than URT, BRT as well as bilateral plyometric training since the mean differences (1.12, 2.99 & 2.13) are higher than CI value (0.90). And also, URT was much better than BRT (MD=1.87) and BPT (MD=1.01) since the mean differences (1.87 & 1.01) are higher than CI value (0.90). Further, insignificant difference were found between BRT and BPT (MD=0.87). Chosen URT, UPT, BRT, BPT & Control group's passing scores are graphically displayed in diagram-4h.

Figure – 4h
Figure Showing Soccer Player's Passing
(AP) of URT, UPT, BRT, BPT & Control Groups



Analysis of Shooting Ability (SA)

The assessed pre and post test shooting ability (SA) scores of URT, UPT, BRT, BPT & Control group's are analyzed as in table 4.25-4.27

Table – 4.25
Paird't' Test and % of Changes on Soccer Player's Shooting Ability (SA) of URT, UPT, BRT, BPT&CG

Groups Name	Testing Periods	Subjects	Mean Values	SD Values	DM Value	't' – test Value	Percentage
Unilateral Resistance	Pre	15	53.73	2.71	10.13	33.05*	18.85
	Post		63.86	3.24			
Unilateral Plyometric	Pre	15	54.00	2.50	12.93	30.03*	23.95
	Post		66.93	2.12			
Bilateral Resistance	Pre	15	53.47	2.67	5.13	8.66*	9.59
	Post		58.60	3.11			
Bilateral Plyometric	Pre	15	53.46	2.66	8.00	14.52*	13.66
	Post		61.46	2.67			
Control	Pre	15	53.06	2.37	0.13	0.12	0.25
	Post		53.20	2.48			

df 14 =2.15 (table value)
*(*significant)*

The assessed pre and post test shooting ability values of four training (URT, UPT, BRT, BPT) groups differ noticeably since the 't' values of URT (33.05), UPT (30.03), BRT (8.66) as well as bilateral plyometric training (BT=14.52) groups were greater than the table value (df14=2.15). Following 12 weeks of URT, UPT, BRT and BPT treatment, soccer player's shooting ability (URT=18.85%, UPT=23.95%, BRT=9.59 and BPT=13.66%), enhanced greatly.

The chosen soccer player's shooting ability of URT, UPT, BRT, BPT and CG groups were analyzed through ANCOVA statistics, and put on view in table–4.26.

Table – 4.26
ANCOVA Statistics Output on Soccer Player's Shooting Ability (SA) of URT, UPT, BRT, BPT & Control Groups

	URT	**UPT**	**BRT**	**BPT**	**CG**	**SoV**	**SS**	**df**	**MS**	**'F' ratio**
Adjusted Mean	63.74	66.63	58.65	61.52	53.52	B	1488.23	4	372.06	80.59*
						W	318.56	69	4.62	

*(Table value for df 4 &69 is 2.50)*Significant (.05 level)*

The ANCOVA statistics result established that the adjusted final means (URT=63.74, UPT=66.63, BRT=58.65, BPT=61.52 & CG=53.52) on soccer player's shooting of all (URT, UPT, BRT, BPT & Control**)** chosen groups differs from one another, because the derived adjusted final mean's 'F' value (80.59) is superior to requisite value (df 4 & 69 =2.50).

As the URT, UPT, BRT, BPT & Control group's adjusted final means 'F' value (F= 80.59) is significant, further statistics Scheffe's Test was calculated and displayed in table-4.27.

Table – 4.27
Scheffe's Test Outcome on Soccer Player's Shooting Ability (SA) of URT, UPT, BRT, BPT & Control Groups

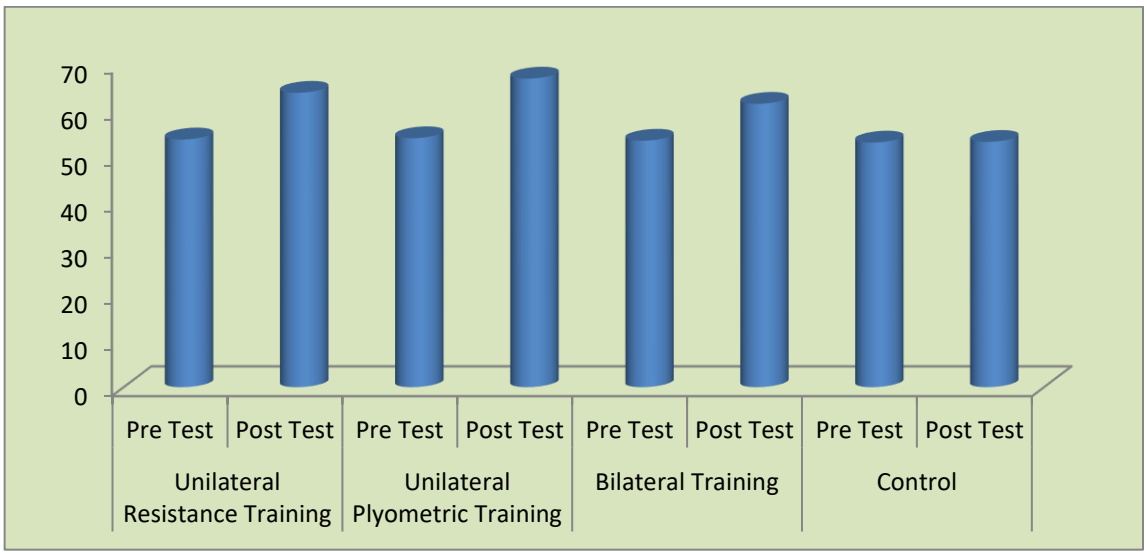
Variable	Unilateral Resistance Training	Unilateral Plyometric Training	Bilateral Resistance Training	Bilateral Plyometric Training	Control	MD	CI
Shooting Ability (SA)	63.74	66.63				2.89*	2.48
	63.74		58.65			5.09*	2.48
	63.74			61.52		2.22	2.48
	63.74				53.52	10.22*	2.48
		66.63	58.65			7.97*	2.48
		66.63		61.52		5.11*	2.48
		66.63			53.52	13.11*	2.48
			58.65	61.52		2.87*	2.48
			58.65		53.52	5.13*	2.48
				61.52	53.52	8.00*	2.48

**Significant (.05)*

It (Scheffe's Test) proved that due to URT (10.22), UPT (13.11), BRT (5.13) as well as bilateral plyometric training (8.00) the soccer player's shooting ability was significantly improved. Though, UPT was much better than URT, BRT as well as bilateral plyometric training since the mean differences (2.89, 7.97 & 5.11) are higher than CI value (2.48). And also, URT is much better than BRT (MD=5.09) and BPT is much better than BRT (MD=2.87). Further, insignificant difference found between URT and BPT (MD=2.22).

Chosen URT, UPT, BT & Control group's shooting scores are graphically displayed in diagram-4i.

Figure – 4i
Figure Showing Soccer Player's Shooting
(AP) of URT, UPT, BRT, BPT & Control Groups



DISCUSSION ON FINDINGS

Due to unilateral and bilateral resistance and plyometric training significant improvement was found on chosen fitness elements and striking variables of soccer players. However, unilateral resistance and plyometric training groups would be better than bilateral resistance and plyometric training groups in improving the chosen fitness elements and striking variables.

Discussion on Unilateral Resistance and Plyometric Training Responses

The results proved that due to unilateral resistance training (URT) and unilateral plyometric training (URT) the chosen fitness elements and striking variables of soccer players were enhanced significantly. Appleby (2019) documented that the smaller base of support of unilateral exercises requires neuromuscular coordination and increased stability; however, this comes at the cost of external loading. Some research also suggests that unilateral training may

reduce muscular imbalances and the overall bilateral deficit (Jansson, 2013). Another theory supporting the incorporation of unilateral exercises in a training program is known as the bilateral deficit. This refers to the difference between the maximal strength of a bilateral contraction and the sum of the strength of the right and left limbs when contracting alone (Costa, 2015). This phenomenon has been observed in both dynamic and isometric contractions, in both the upper and lower limbs, large and small muscle groups, and in populations including athletes, non-athletes, elderly, and adolescents (Jansson, 2013; Costa, 2015).

There are many theories regarding the cause of the increased force capacity of unilateral contractions compared to the two limbs contracting in tandem. One possible explanation as to the origin of the deficit is the difference in antagonist muscle activation between unilateral and bilateral contractions (Kuruganti, 2011). It may also be more complicated for the body to fully activate the largest and strongest motor units during bilateral contractions, as this requires coordinated neural impulses from both of the brain's hemispheres. Therefore, it is theorized that unilateral training may be a more efficient means of training if maximal speed and strength production presents a challenge to the neuromuscular system (Jansson, 2013).

Recently, it was observed that following 6 weeks of unilateral PT, but not after bilateral PT, there was a significantly larger performance change in jumping ability and power (Makaruk et al., 2011). Similarly, unilateral PT increased leaping performance more than bilateral PT. Unilateral exercises, on the other

hand, were equally effective in improving unilateral and bilateral leg strength and power (McCurdy et al., 2005) or even causing a faster rate of force development, lower vertical ground reaction forces, significantly longer contact times and when compared to bilateral training (Cappa & Behm, 2011). All of these findings point to bilateral exercises as a more targeted power training practise for many of the reported jump as well as sprint actions seen during soccer games.

In adults, there is evidence that unilateral plyometric exercise is more successful than bilateral plyometric training (Bogdanis, Donti, et al., 2019). This type of plyometric training may lead to larger performance gains, particularly in sports that require unilateral explosive muscular motions (sprinting, jumping, and changing directions) (Appleby et al., 2020). Furthermore, unilateral plyometric activities increase neuromuscular activation and, as a result, may diminish performance side asymmetries (Ramirez-Campillo et al., 2018). Unilateral plyometric training has not been widely investigated in young athletes, despite its potential to bestow significant benefits in explosive performance. In the limited trials in children, bilateral plyometric exercise was performed alone or in combination with resistance training (Ribeiro et al., 2019; Meylan & Malatesta, 2009; Faigenbaum et al., 2007). Only one study investigated bilateral, unilateral, and combined plyometric training in youth (11-year-old) soccer players and found that combined unilateral and bilateral plyometric training was

more successful in developing muscle strength and balance performance (Ramirez-Campillo et al., 2015).

Furthermore, in addition to the likely greater improvement in intra-muscular coordination (changes in motor-unit synchronisation & activation) with UPT compared to BPT (Bouguezzi et al., 2018; Markovic & Mikulic, 2010), there may also be a greater improvement in inter-muscular coordination (better synergistic muscle recruitment strategies) with UPT (Markovic & Mikulic, 2010). In addition, when compared to double-leg jumps, single-leg training is characterised by slower muscular contractions, allowing for the creation of substantially larger forces (Bobbert et al., 2006). The slower muscular contractions, based on the force-velocity curve, would allow muscles to function closer to their optimum velocity and generate more power and impulse, resulting in higher adaptations than the faster bilateral jumps (Bobbert et al., 2006; Wilson et al., 1993; Van Soest et al., 1985; McBride et al., 2002).

The greater improvement in vertical as well as horizontal jumping performance after UPT has previously been observed in adults (Bogdanis, et al., 2019). This could be explained by training specificity, as this group was only trained with single-leg jumps, or by the larger load imposed on the leg extensor muscles during the single-leg jumps supporting the whole body (Bobbert et al., 2006). One probable explanation for the hamstring muscles' improvement is their role in knee joint stabilisation during single leg plyometric workouts (Hewett et al., 1996). Thus, increased activation of the hamstring muscles during single-leg

plyometric training may be the underlying mechanisms for the greater improvement reported in the UPT group, due to both the greater stability effort that they execute and the 2-fold greater load of maintaining the whole body weight.

The main argument for the use of unilateral exercises is their greater specificity and potential transfer to sport-specific movements like running, bounding, jumping, and changing directions which are entirely or predominately unilateral. Specificity is a key principle in program design to maximize the transfer between training and competitive performance. Therefore, to most effectively improve performance, it is argued that unilateral resistance and plyometric exercises must closely resemble the forces and mechanics required for the specific sport.

Discussion on Bilateral Resistance and Plyometric Training Responses

The present findings proved that due to bilateral resistance and plyometric training (UPT) the chosen fitness elements and striking variables of soccer players were enhanced significantly. Previous findings demonstrated that both bilateral and unilateral exercises demonstrate improvements in their trained movement and proved to be equally effective in increasing strength (Appleby, 2019; McCurdy, 2005; Spiers, 2016). Improvements in both strength and power using bilateral exercises, such as the back squat, have been established and are commonly used as a primary exercise for this reason (Spiers, 2016).

While one modality did not prove to be significantly more effective in increasing strength than the other, there was a noted reciprocal benefit: bilateral training also improved performance on unilateral tests and unilateral training also improved performance on bilateral tests (Appleby, 2019; McCurdy, 2005; Spiers, 2016). Although the exact mechanism for this finding is unclear, the improvements in strength likely have a carryover effect between tests. Even with the carryover effect, greater improvements in strength were seen on the specific test modality the athletes trained for, likely due to the mechanical specificity between the training stimulus and test (Appleby, 2019).

Ramrez-Campillo et al., (2015) conducted an interesting study in which they compared the effects of unilateral and bilateral plyometric exercises, as well as their combination, on measures of vertical and horizontal jumping performance, sprint ability, and static balance in 11.4-year-old soccer players. Despite the short duration of the training intervention (just 6 weeks), all three training procedures significantly improved numerous performance indicators. However, they found that the combined unilateral and bilateral training group outperformed the control group in 13 of the 21 performance measures, while the unilateral and bilateral training groups outperformed the control group in only 6 and 3 of them, respectively (Ramrez-Campillo et al., 2015). Although this finding supports the use of bilateral and unilateral exercises in child soccer players, a close examination of the results of the study by Ramrez-Campillo et al., (2015) reveals that the only performance measures that were better in the

combined training compared to unilateral training were three balance tests and two-legged tests (double-leg horizontal jump DJ & CMJ). Both unilateral and combination training had the same effects in the remaining performance measures (agility, kicking, bounds & single leg jumps).

Both the UPT and BPT groups increased their double leg jumps (sarjent jump). This is also consistent with earlier research in adults (Bogdanis et al., 2019) and children (Tottori and Fujita, 2019; Bogdanis et al., 2019; Michailidis et al., 2013; Johnson et al., 2011). Following an 8-week plyometric training programme during the competitive season, Meylan and Malatesta (2009) discovered an increase in CMJ (+7.9%) among young soccer players. Other studies, on the other hand, have seen substantially bigger improvements (15-20%) (Bouguezzi et al., 2018; Michailidis et al., 2013; Thomas et al., 2009). The disparity between studies in terms of the extent of gain in leaping performance could be due to pre-training fitness and, more importantly, the individuals' maturation status (Moran et al., 2017).

Bilateral exercises allow for greater loading; therefore, the production of greater absolute force. This peak force production helps improve the athlete’s strength which is a key indicator of athletic performance and a main goal in most training programs. Bilateral exercises also allow for greater stability because the center of mass can be balanced between both limbs. These exercises require the coordination between both sides of the body and can be used to train both sides of the body simultaneously. Additionally, bilateral exercises may be easier to

teach and perform, especially for novice athletes, and can be used as a safe option for even inexperienced athletes.

Summary

Both bilateral and unilateral exercises can elicit improvements in fitness elements and striking variables of soccer players, both can and should be incorporated in an athlete's training program. Bilateral exercises will allow for the use of greater absolute loads and greater overall force production. While unilateral exercises will require lighter absolute loads than a bilateral exercise, the relative intensity may be greater than the bilateral movement and could enhance force development in a way that better corresponds to sport-specific strength gains (Jones, 2012). Another reason unilateral exercise requires lighter loads is because of the increased stability required to perform the exercise. Therefore, they may be less effective for the development of maximal strength, but can be used to complement and transfer strength gains to bilateral exercises (Appleby, 2019). Also, using unilateral exercise alters the training stimulus which may also enhance recovery and reduce the risk of overuse injury while still providing a similar training result to a bilateral exercise (Jones, 2012). Practically, research suggests that both unilateral and bilateral exercises should be used as complimentary components of a training program as a means of increasing fitness elements and striking variables of soccer players.

In conclusion, the present study showed that unilateral plyometric training, unilateral resistance training (URT) and bilateral resistance and

plyometric training (BRPT) performed thrice per week for 12 weeks, enhances various measures of fitness elements and striking variables of soccer players. This could be attributed to larger neuromuscular adaptations as a result of the higher load delivered and/or the training specificity during single leg exercise regimes. Unilateral plyometric training may be a highly effective and safe training strategy for optimising fitness aspects and striking characteristics of soccer players due to the nature of the game, which requires explosive single-leg actions. As a result, it is possible to argue that unilateral plyometric training is superior to bilateral plyometric training. This assumption is based on the nature of soccer motions, which are mostly unilateral (e.g., accelerations, kicks, and changes of direction) and only occasionally bilateral (e.g. double leg jump for a header). In this regard, unilateral plyometric training may be more effective in the long run for optimizing lower-limb neuromuscular function, but further research is needed.

DISCUSSION ON HYPOTHESES

At first it was hypothesized significant improvement would be there on chosen fitness elements and striking variables of soccer players due to URT. The results proved that due to URT the chosen fitness elements and striking variables of soccer players were enhanced significantly. Hence, it was accepted.

The 2nd framed hypothesis was that significant improvement would be there on chosen fitness elements and striking variables of soccer players due to unilateral plyometric training (UPT). The results proved that due to unilateral

plyometric training (UPT) the chosen fitness elements and striking variables of soccer players were enhanced significantly. Hence, it was accepted.

The framed 3rd hypothesis was that significant improvement would be there on chosen fitness elements and striking variables of soccer players due to bilateral resistance training (BRT). The results proved that due to bilateral resistance training (BRT) the chosen fitness elements and striking variables of soccer players were enhanced significantly. Hence, it was accepted.

The fourth hypothesis was that there would be significant improvement on chosen fitness elements and striking variables of soccer players due to bilateral plyometric training (BPT). The results proved that due to bilateral plyometric training (BPT) the chosen fitness elements and striking variables of soccer players were enhanced significantly. Hence, it was accepted.

The fourth hypothesis was that the unilateral plyometric training would be better than unilateral resistance training (URT) and bilateral resistance (BRT) and plyometric training (BPT) in improving the chosen fitness elements and striking variables. The results proved that, unilateral plyometric training was better than unilateral resistance training (URT) and bilateral resistance and plyometric training (BRPT) in improving all the chosen fitness elements and striking variables except muscular strength. Hence, it was partially accepted.

Chapter V

SUMMARY CONCLUSION AND RECOMMENDATIONS

SUMMARY

Soccer is the most popular and widely watched sport on the planet, as well as one of the most diverse in terms of energy systems, performance metrics, and movement variation. Soccer, in particular, necessitates varying degrees of aerobic and anaerobic energy systems based on the game plan, opponent, and position played by the athlete. Despite the fact that soccer involves a lot of high-intensity movements like short-distance and short-duration sprints (speed) and quick changes of direction (agility), most coaches, players, and fans regard it as an endurance sport.

Cardiovascular endurance training might be stressed as a fundamental aspect of practise, an offseason training programme, or on an individual basis in a collegiate or professional setting. Off-field training such as lifting weights, plyometrics, and power training would receive less attention from most soccer coaches, programmes, and organisations due to this emphasis on cardiovascular endurance. Despite the fact that endurance training receives the most attention, several studies have shown that strength and plyometric training can improve jump height and speed while having no negative impact on cardiovascular endurance (Siegler, Gaskill, & Ruby, 2003; Gorostiaga et al., 2004). In young female soccer players, a strength and plyometric programme enhanced power endurance and speed over aerobic training alone, and soccer-specific power

endurance training could improve match performance and reduce tiredness (Siegler et al., 2003)

Soccer needs several single leg, or unilateral activities, such as running, cutting, jumping, kicking, twisting, and bracing against a defender, over a lengthy period of time in addition to energy system development. When a player dribbles, passes, or shoots the ball, one leg is dominant in order to powerfully move the ball while the other leg supports the body weight (Oshita & Yano, 2010). A prior study used a 12-week training regimen that included single and double leg plyometric exercises as a supplement to soccer drills, and found that participants improved their speed and jumping abilities (Michailidis et al., 2013). Only a few studies have coupled bilateral plyometric training with resistance training (Ribeiro et al., 2019; Meylan & Malatesta, 2009; Faigenbaum et al., 2007).

To analyze the impact of unilateral and bilateral resistance and plyometric training on chosen fitness elements and striking variables 75soccer players of age from 18 to 21 years were chosen from Mohammed Sathak AJ Engineering College, Siruseri, Chennai and Hindustan College of Arts and Science, Padur, Chennai. Participants were randomly assigned to five different training groups (15 in each group). Group-I performed Unilateral Resistance Training [URT], Group-II performed Unilateral polymeric training [UPT], group-III performed Bilateral Resistance Training [BRT], group-IV performed Bilateral plyometric Training [BPT] and group-V was control[CG]. The 4experimental groups

participants were experimental treatment during morning session, only 3 days in a week for 12 weeks, duration.

This study was delimited to the Fitness Elements and tests such as Muscular Strength [I RM Test], Anaerobic Power [RAST], Abdominal Strength Endurance [Sit ups], Explosive Power - Vertical [Sergeant Jump]. This study was also delimited to the Striking Variables and Tests such as Kicking [Mor MC Donald Soccer test], Dribbling [Mor-Christian dribbling Test], Passing [Mor-Christian Passing Test] and Shooting abilities, [Mor-Christian Shooting Test].

The collected 2 tests (pre & post) data on all chosen dependent variables (fitness elements & striking variables) from the 5groups (4 experimental and 1 control) were analyzed by paired 't' test and Analysis of Covariance (ANCOVA) statistics. Since five groups were involved, whenever the derived post test (adjusted) means 'F' ratio value was found to be significant, the post hoc test (Scheffe's) was applied. The level of confidence for significance was set at 0.05 level. Additionally, percentage of improvement in fitness elements and striking variables due to experimental treatment was also calculated.

RESULT OF THE STUDY

The derived findings are as follows

Muscular Strength (MS)

Due to unilateral resistance (URT=26.19%), unilateral plyometric (UPT=14.89%), bilateral resistance (BRT=18.07%) as well as bilateral

plyometric training (BPT=9.74%) the soccer player's muscular strength was greatly improved. Though URT was much better than UPT, BRT and bilateral plyometric training and also bilateral resistance training was greater than bilateral plyometric training. Whereas insignificant differences were found between UPT and BRT and also between UPT and BPT groups.

Anaerobic Power (AP)

The soccer player's anaerobic power was greatly improved due to unilateral resistance (URT=7.06%), unilateral plyometric (UPT=12.12%), bilateral resistance (BRT=5.66%) as well as bilateral plyometric training (BPT=8.55%).

However, UPT was much better than BPT, URT and bilateral resistance training. Further, URT was much better than bilateral resistance training and bilateral plyometric training was better than unilateral resistance and bilateral resistance training.

Strength Endurance (SE)

As a results of unilateral resistance (URT=25.60%), unilateral plyometric (UPT=11.15%), bilateral resistance (BRT=18.43%) as well as bilateral plyometric training (BPT=18.51%) the soccer player's strength endurance was greatly improved. URT was much better than UPT, bilateral resistance training and bilateral plyometric training. Further, bilateral resistance (BRT) and plyometric training (BPT) groups are better to UPT training whereas insignificant difference was found between bilateral resistance (BRT) and plyometric training (BPT).

Vertical Explosive Power (VEP)

Due to unilateral resistance (URT=7.23%), unilateral plyometric (UPT=16.60%), bilateral resistance (BRT=6.41%) as well as bilateral plyometric training (BPT=5.13%) the soccer player's explosive power was greatly improved. UPT was much better than URT, bilateral resistance training and bilateral plyometric training. Further, bilateral plyometric training (BPT) is better to BRT and URT training whereas insignificant difference was found between bilateral resistance (BRT) and unilateral resistance training (URT).

Aerobic Fitness (AF)

The soccer player's aerobic fitness was significantly improved due to unilateral resistance (URT=6.52%), unilateral plyometric (UPT=5.48%), bilateral resistance (BRT=8.06%) well as bilateral plyometric training (BPT=5.89%). Though, UPT was much better than URT, BRT and bilateral plyometric training. Further, URT was better than BRT and bilateral plyometric training (BPT) and BPT was better than BRT.

Kicking Ability (KA)

Due to 12 weeks of URT, UPT BRT and BPT treatment, soccer player's kicking performance (URT=10.57%, UPT=10.94% BRT=3.31% and BPT=6.05%), enhanced greatly. Though UPT was much better than URT, BRT as well as bilateral plyometric training. Whereas insignificant differences were found between URT and BRT groups, URT and BPT groups and also between BRT and BPT groups.

Dribbling Ability (DA)

Due to 12 weeks of URT, UPT, BRT and BPT treatment, soccer player's dribbling performance (URT=12.93%, UPT=25.97% BRT=4.28% and BPT=6.80%), enhanced significantly. Though, UPT was much better than URT, BRT as well as bilateral plyometric training. And also URT was much better than BRT whereas, insignificant differences were found between URT and BPT groups and also between BRT and BPT groups.

Passing Ability (PA)

Due to 12 weeks of URT, UPT, BRT and BPT treatment, soccer player's Passing ability (URT=25.91%, UPT=34.58%, BRT=17.47% and BPT=30.92%), increased significantly. Though, UPT was much better than URT, BRT as well as bilateral plyometric training. And also, URT was much better than BRT and BPT however insignificant difference were found between BRT and BPT groups.

Shooting Ability (SA)

Due to 12 weeks of URT, UPT, BRT and BPT treatment, soccer player's shooting ability (URT=18.85%, UPT=23.95% BRT=9.59% and BPT =13.66%), enhanced greatly. Though, UPT was much better than URT, BRT as well as bilateral plyometric training. And also, URT is much better than BRT and BPT is much better than BRT. Further, insignificant difference found between URT and BPT groups.

CONCLUSION

The current study's findings have significant practical implications for soccer players. It reveals that when compared to bilateral resistance (BRT) and bilateral plyometric training, unilateral plyometric training (UPT) and unilateral resistance training programmes of short duration performed thrice weekly are more beneficial for enhancing fitness aspects and striking characteristics (BPT). This could be attributed to larger neuromuscular adaptations as a result of the higher load delivered and/or the training specificity during single leg exercise regimes. Unilateral training may be a highly effective and safe training modality for optimizing fitness aspects and striking characteristics of soccer players due to the nature of the game, which requires explosive single-leg motions. As a result, soccer coaches can safely use unilateral plyometric and resistance workouts in the major part of the training session to improve soccer players' game-specific fitness and skill performance.

RECOMMENDATIONS

1. The outcomes of this investigation may provide insight regarding the role of unilateral and bilateral resistance and plyometric training for enhancing soccer performance.
2. To enhance adaptations, soccer players should combine unilateral and bilateral workouts conducted in different planes during training (i.e., vertical, horizontal, lateral).

3. Although training adaptations showed a specificity impact, in sports where performance is primarily dependent on unilateral or bilateral movements, this movement pattern should be used in a large percentage of exercises. A combination of cyclic and acyclic jumps (with a slight increase in volume over time) may also be beneficial to performance adaptations.
4. While PT can improve explosive, endurance, and balance performance in young soccer players, this training strategy should be properly applied in a more complex training plan that includes other explosive (e.g., sprints), endurance, technical, and tactical-oriented training methods to maximize training adaptations.
5. A lengthier training programme may be required, based on the optimistic tendencies of the unilateral training group in this study and more successful earlier study interventions.
6. Future studies should look on increasing the frequency of unilateral (as opposed to bilateral) training exposure.
7. Future research should utilize separate exercises with similar movement patterns but the only contrast being whether it is single or double leg variation.
8. Future studies should look at a variety of sports that include a variety of athletes. Because soccer uses such a complicated collection of energy systems and many soccer programmes focus on endurance rather than

strength, it would be interesting to compare different types of athletes, particularly strength athletes such as football and baseball, to see if they could develop more than soccer.

9. Using other athletes in research could help to increase the validity and reliability of unilateral versus bilateral training motions on a wide scale across all performance training programmes.
10. Although this study indicated the benefits of a unilateral programme in terms of power, speed, and agility, additional research is needed to evaluate whether it is indeed a better programme than a standard bilateral-based programme.

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APPENDIX – I

CONSENT FORM FOR THE PROPOSED RESEARCH STUDY

Name:

Course:

Mr. **S. Tubin**, Ph.D scholar in the department of Physical Education, Annamalai University has requested my participation in a research study at this institution. The title of the research is "**Impact of Unilateral and Bilateral Resistance and Plyometric Training on Selected Fitness Elements and Striking Variables among Soccer Players**".

I have informed the purpose of this research. My participation is involved in various training like resistance training and plyometric training three days in a week for twelve weeks one and half hours from 6 am to 7.30 am. I understand that there are possible benefits due to participation in this research.

I have been advised that the research in which I will be participating does not involve more than minimal risks. I have been informed that I will not be compensated for my participation.

I have read the above information, the nature; demands, risks and benefits of the research have been explained to me. I knowingly assume the risks involved and understand that I may withdraw my consent and discontinue participation at any time without penalty, or loss of benefit to myself. In signing this consent form, I am not to wave any legal commends raised or remedies. A copy of the consent form is given to me.

Date: Participant's Signature

Certificate by Researcher

I certify that, I have explained to the above individual, the nature and purpose, the potential benefits and possible risks associated with participation in this research study, have answered any questions that have been raised and witnessed the above signature.

These elements of informed consent conformed to the assurance given by Department of Physical Education, Annamalai University to protect the rights of human subjects. I have provided the subject or copy of the signed consent documents.

Date: Signature of the Investigator

APPENDIX – II

UNILATERAL RESISTANCE TRAINING SCHEDULE

Week	Day	Exercise	Inten-sity	Sets	Rep	Rest between	
						Exe.	Set
I & II	Mon	Single-arm dumbbell shoulder presses, Single-leg Squats, Single-arm lateral raises, Single-leg Curl, Single-arm triceps extension & biceps curl, Single-leg Press	65%	3	14 (7each)	1:1	1:3
	Wed			3	14 (7each)	1:1	1:3
	Fri			3	14 (7each)	1:1	1:3
III & IV	Mon	Single-arm dumbbell shoulder presses, Single-leg Squats, Single-arm lateral raises, Single-leg Curl, Single-arm triceps extension & biceps curl, Single-leg Press	70%	3	12 (6each)	1:1	1:3
	Wed			3	12 (6each)	1:1	1:3
	Fri			3	12 (6each)	1:1	1:3
V & VI	Mon	Single-arm dumbbell shoulder presses, Single-leg Squats, Single-arm lateral raises, Single-leg Curl, Single-arm triceps extension & biceps curl, Single-leg Press	75%	3	10 (5each)	1:1	1:3
	Wed			3	10 (5each)	1:1	1:3
	Fri			3	10 (5each)	1:1	1:3
VII & VIII	Mon	Single-arm dumbbell shoulder presses, Single-leg Squats, Single-arm lateral raises, Single-leg Curl, Single-arm triceps extension & biceps curl, Single-leg Press	80%	3	8 (4each)	1:1	1:3
	Wed			3	8 (4each)	1:1	1:3
	Fri			3	8 (4each)	1:1	1:3
IX & X	Mon	Single-arm dumbbell shoulder presses, Single-leg Squats, Single-arm lateral raises, Single-leg Curl, Single-arm triceps extension & biceps curl, Single-leg Press	85%	3	6 (3each)	1:1	1:3
	Wed			3	6 (3each)	1:1	1:3
	Fri			3	6 (3each)	1:1	1:3
XI & XII	Mon	Single-arm dumbbell shoulder presses, Single-leg Squats, Single-arm lateral raises, Single-leg Curl, Single-arm triceps extension & biceps curl, Single-leg Press	90%	3	4 (2each)	1:1	1:3
	Wed			3	4 (2each)	1:1	1:3
	Fri			3	4 (2each)	1:1	1:3

APPENDIX – III
BILATERAL RESISTANCE TRAINING SCHEDULE

Week	Day	Exercise	Intensity	Sets	Rep	Rest between	
						Exe.	Set
I & II	Mon	Bilateral barbell front squat, Barbell shoulder press, Leg press, Biceps curls and triceps extensions, Bilateral bench presses Deadlift	65%	3	14	1:1	1:3
	Wed			3	14	1:1	1:3
	Fri			3	14	1:1	1:3
III & IV	Mon	Bilateral barbell front squat, Barbell shoulder press, Leg press, Biceps curls and triceps extensions, Bilateral bench presses Deadlift	70%	3	12	1:1	1:3
	Wed			3	12	1:1	1:3
	Fri			3	12	1:1	1:3
V & VI	Mon	Bilateral barbell front squat, Barbell shoulder press, Leg press, Biceps curls and triceps extensions, Bilateral bench presses Deadlift	75%	3	10	1:1	1:3
	Wed			3	10	1:1	1:3
	Fri			3	10	1:1	1:3
VII & VIII	Mon	Bilateral barbell front squat, Barbell shoulder press, Leg press, Biceps curls and triceps extensions, Bilateral bench presses Deadlift	80%	3	8	1:1	1:3
	Wed			3	8	1:1	1:3
	Fri			3	8	1:1	1:3
IX & X	Mon	Bilateral barbell front squat, Barbell shoulder press, Leg press, Biceps curls and triceps extensions, Bilateral bench presses Deadlift	85%	3	6	1:1	1:3
	Wed			3	6	1:1	1:3
	Fri			3	6	1:1	1:3
XI & XII	Mon	Bilateral barbell front squat, Barbell shoulder press, Leg press, Biceps curls and triceps extensions, Bilateral bench presses Deadlift	90%	3	4	1:1	1:3
	Wed			3	4	1:1	1:3
	Fri			3	4	1:1	1:3

APPENDIX – IV
UNILATERAL PLYOMETRIC TRAINING SCHEDULE

Week	Plyometric Drills	Training Intensity	Sets X Rep.	Training Volume (Foot contacts)	Rest between	
					Exe.	Set
I & II	Single leg lateral jump	Low	2 X 14	90 (45 each)	1:1	1:3
	Single arm over hand medicine ball throw	Low	2 X 16		1:1	1:3
	Single-leg vertical jump (high)	Low	5 X 6		1:1	1:3
III & IV	Single leg countermovement jump	Low	2 X 14	120 (60 each)	1:1	1:3
	single leg Hops	Low	5 X 6		1:1	1:3
	Single arm over hand medicine ball throw	Medium	2 X 16		1:1	1:3
	Single leg jump over hurdle	Medium	5 X 6		1:1	1:3
V & VI	Single leg drop jump	Low	2 X 12	120 (60 each)	1:1	1:3
	Single leg hops	Low	4 X 6		1:1	1:3
	Single arm over hand medicine ball throw	Medium	2 X 12		1:1	1:3
	Single leg jump over hurdle	Medium	3 X 8		1:1	1:3
	Underhand vertical medicine ball throw (Single arm)	Medium	2 X 12		1:1	1:3
VII & VIII	Single leg drop jump	Low	4 X 8	140 (70 each)	1:1	1:3
	Single leg hops	Medium	4 X 8		1:1	1:3
	Single arm over hand medicine ball throw	Medium	2 X 12		1:1	1:3
	single leg jump over hurdle	High	4 X 7		1:1	1:3
	Underhand vertical medicine ball throw (Single arm)	High	4 X 6		1:1	1:3
IX & X	single leg countermovement jump	Low	2 X 7	140 (70 each)	1:1	1:3
	Single leg drop jump	Medium	4 X 7		1:1	1:3
	Single leg hops	Medium	4 X 7		1:1	1:3
	Single arm over hand medicine ball throw	Medium	4 X 7		1:1	1:3
	Single leg jump over hurdle	High	4 X 7		1:1	1:3
	Underhand vertical medicine ball throw (Single arm)	High	2 X 7		1:1	1:3
XI & XII	Single leg drop jump	Low	2 X 12	120 (60 each)	1:1	1:3
	Single leg hops	Low	2 X 12		1:1	1:3
	Single arm over hand medicine ball throw	Medium	4 X 6		1:1	1:3
	Single leg jump over hurdle	Medium	3 X 8		1:1	1:3
	Underhand vertical medicine ball throw (Single arm)	High	4 X 6		1:1	1:3

APPENDIX – V
BILATERAL PLYOMETRIC TRAINING SCHEDULE

Week	Plyometric Drills	Training Intensity	Sets X Rep.	Training Volume (Foot contacts)	Rest between	
					Exe.	Set
I & II	Squat jump	Low	2 X 14	90	1:1	1:3
	Clapping push ups	Low	2 X 16		1:1	1:3
	Box jump	Low	5 X 6		1:1	1:3
III & IV	Burpees	Low	2 X 14	120	1:1	1:3
	Tuck jumps	Low	5 X 6		1:1	1:3
	Double arm over hand medicine ball throw	Medium	2 X 16		1:1	1:3
	Double leg jump over hurdle	Medium	5 X 6		1:1	1:3
V & VI	Double leg drop jump	Low	2 X 12	120	1:1	1:3
	Tuck jumps	Low	4 X 6		1:1	1:3
	Double arm over hand medicine ball throw	Medium	2 X 12		1:1	1:3
	Double leg jump over hurdle	Medium	3 X 8		1:1	1:3
	Underhand vertical medicine ball throw (double arm)	Medium	2 X 12		1:1	1:3
VII & VIII	Double leg drop jump	Low	4 X 8	140	1:1	1:3
	Tuck jumps	Medium	4 X 8		1:1	1:3
	Double arm over hand medicine ball throw	Medium	2 X 12		1:1	1:3
	Double leg jump over hurdle	High	4 X 7		1:1	1:3
	Underhand vertical medicine ball throw (double arm)	High	4 X 6		1:1	1:3
IX & X	Squat jump	Low	2 X 7	140	1:1	1:3
	Double leg drop jump	Medium	4 X 7		1:1	1:3
	Tuck jumps	Medium	4 X 7		1:1	1:3
	Double arm over hand medicine ball throw	Medium	4 X 7		1:1	1:3
	Double leg jump over hurdle	High	4 X 7		1:1	1:3
	Underhand vertical medicine ball throw (double arm)	High	2 X 7		1:1	1:3
XI & XII	Double leg drop jump	Low	2 X 12	120	1:1	1:3
	Tuck jumps	Low	2 X 12		1:1	1:3
	Double arm over hand medicine ball throw	Medium	4 X 6		1:1	1:3
	Double leg jump over hurdle	Medium	3 X 8		1:1	1:3
	Underhand vertical medicine ball throw (double arm)	High	4 X 6		1:1	1:3

IMPACT OF UNILATERAL AND BILATERAL RESISTANCE AND PLYOMETRIC TRAINING ON SELECTED FITNESS ELEMENTS AND STRIKING VARIABLES AMONG SOCCER PLAYERS

Thesis

Submitted by

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in partial fulfilment of the requirements for the award of the degree of

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IN
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DEPARTMENT OF PHYSICAL EDUCATION

ANNAMALAI UNIVERSITY

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TAMILNADU, INDIA

2022

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PLYOMETRICS

SCIENCE for SPORT

Key information

Plyometric training involves the usage of jumps, hops, bounds, and/or skips. This form of training is governed by the stretch-shortening cycle (SSC), and therefore should not be confused with ballistic training.

SSC

In the SSC the muscle undergoes an eccentric contraction, followed by a transitional period (amortisation phase), prior to the concentric contraction.

Short vs Long

Plyometric exercises can be classified as short (<0.25s) or long (>0.25ls).

Performance

Plyometrics can improve physical characteristics, including but not limited to:

- Strength
- Power
- Speed
- Jumping

Neurophysiology

There are many potential mechanisms underpinning the performance enhancing effects of plyometrics including but not limited to:

- Storage and use of elastic energy
- Motor coordination

Caution

Plyometrics are highly coordinated and potentially high intensity movements they therefore require careful attention.

Our Summary

Plyometric training develops the neural and musculotendinous systems of the SSC to generate maximal force in the shortest amount of time. Therefore plyometrics are often used in strength and speed training.

For the full article check out the Science for Sport website

SCIENCE for SPORT

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"When I lost all of my excuses, I found all of my results."

"Attract what you want by being what you want."